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of Transportation

United States
Coast Guard

Report of the International Ice Patrol in the North Atlantic

INTERNATIONAL
ICE PATROL

1983 Season
Bulletin No. 69
CG-188-38

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Bulletin No. 69

REPORT OF THE INTERNATIONAL ICE PATROL SERVICES IN THE NORTH ATLANTIC OCEAN

Season of 1983

CG-188-38

FOREWORD

Forwarded herewith is Bulletin No. 69 of the International Ice Patrol describing the Patrol's services, ice observations, and conditions during the 1983 season.

N. C. VENZKE
Chief, Office of Operations

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Summary

From 28 February to 27 August 1983, the International Ice Patrol (IIP), an office of the U. S. Coast Guard, conducted the International Ice Patrol Service, which has been provided annually since the sinking of the RMS TITANIC on April 15, 1912. During past years, Coast Guard ships and/or aircraft have patrolled the shipping lanes off Newfoundland within the area 40°N - 52°N, 39°W - 57°W, detecting icebergs and warning mariners of these hazards. During the 1983 Ice Patrol season, Coast Guard HC-130 aircraft deployed out of Gander, Newfoundland to search for icebergs in the Grand Banks region of the North Atlantic. These aircraft flew 73 ice reconnaissance sorties logging over 427 flight hours. A total of 1352 icebergs were sighted south of 48°N latitude by aircraft and ships transiting the area. This was well above the annual average of 381. New detection equipment, the AN/APS-135 Side Looking Airborne Radar (SLAR), was introduced into Ice Patrol duty during the 1983 season. It proved to be an excellent tool for the detection of both icebergs and sea ice, and provided 97 percent of the 1983 iceberg sightings. The iceberg population was greater then normal this year due, in part, to lower than normal temperatures recorded throughout Newfoundland and Labrador which hindered the melting process of the sea ice and extended its limits farther south. A combination of northerly winds in the Labrador Sea combined with generally southwesterly and westerly winds off the Newfoundland coast also hindered the breakup of the sea ice, which protected the icebergs, allowing them to drift farther south and in larger numbers.

Oceanographic conditions were monitored during the ice season through the use of seven Tiros Oceanographic Drifters (TOD) which supplied real time current information to the IIP. In cooperation with the U. S. Coast Guard Research and Development Center, three icebergs were tracked via satellite using Tiros Arctic Drifters (TAD) for periods of over two months. The information provided by TOD and TAD drifts (see Figures B-1 and B-2) was extremely useful in updating the iceberg drift model (IBERG) which is utilized to update iceberg positions in the Grand Banks region until they either melt or break up. Another oceanographic innovation during the 1983 Ice Patrol season was the development and use of a computer program to model iceberg deterioration. This deterioration model was conservatively used to elimimate icebergs from the drift plot based upon wave, sea surface temperature, and wind convective effects.

Introduction

This is the 69th annual report on the International Ice Patrol Service in the North Atlantic. It contains information on ice conditions and Ice Patrol operations for 1983. The U. S. Coast Guard conducts the International Ice Patrol Service in the North Atlantic Ocean under the provisions of Title 46, U. S. Code, Sections 738, 738a through 738d, and the International Convention for the Safety of Life at Sea (SOLAS), 1960, regulations 5-8. This service has been provided annually since the sinking of the RMS TITANIC on April 15, 1912. Commander, International Ice Patrol, working under Commander, Coast Guard Atlantic Area, directed the International Ice Patrol from offices located at Governors Island, New York. The office analyzes ice and environmental data, prepares the daily ice bulletins and facsimile charts, and replies to any requests for special ice information. It also controls the aerial Ice Reconnaissance Detachment and any surface patrol cutters when assigned, both of which patrol the southeastern, southern and southwestern limits of the Grand Banks region (40°N to 52°N and 39°W to 57°W) for icebergs.

Vice Admiral Wayne E. Caldwell, U. S. Coast Guard, was Commander, Atlantic Area during the 1983 Ice Patrol season. Commander J. J. McClelland, Jr., U. S. Coast Guard, was Commander, International Ice Patrol until he was relieved on 15 July 1983. Lieutenant Commander A. D. Summy, U. S. Coast Guard was Acting Commander, International Ice Patrol from then until the season's end on 26 August 1983.

Two pre-season deployments were made from 26-29 January 1983 and 10-14 February 1983 to determine the early season iceberg distribution. Based on these trips, regular deployments started on 18 February with the 1983 season officially opening on 22 February.

From that date until 27 August 1983, an aerial Ice Reconnaissance Detachment (ICERECDET) operated from Gander, Newfoundland, one week out of two during the season. The season officially closed on 26 August 1983.

No U. S. Coast Guard cutters were deployed to act as surface patrol vessels this year. The USCGC NORTHWIND was deployed to provide oceanographic support to Ice Patrol from 21-27 March 1983.

During the 1983 season, an estimated 1352 icebergs drifted south of 48°N latitude. Table 1 shows monthly estimates of icebergs that crossed 48°N.

Table 1

Estimated Number of Icebergs South of Latitude 48 Degrees N, 1983 Season

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1983	0	0	2	9	165	124	339	465	168	76	4	0
Total 1946-1983	2	4	13	74	437	1296	3470	3358	2033	565	104	10
Average 1946-1983	0	0	0	2	12	35	94	91	55	15	3	0
Total 1900-1983	109	110	93	194	889	3398	8315	10541	5551	1761	493	256
Average 1900-1983	1	1	1	2	11	41	100	127	67	21	6	3

Data Collection and Dissemination

During the 1983 Ice Patrol season (1 October 1982 through 30 September 1983), 117 aircraft sorties were flown in support of the International Ice Patrol. These included pre-season flights, ice observation and logistics flights during the season, and post-season flights. Pre-season flights determined iceberg concentrations north of 48°N, necessary to estimate the time when icebergs would threaten the North Atlantic shipping lanes in the vicinity of the Grand Banks of Newfoundland. During the active season, ice observation flights located the southwestern, southern, and southeastern limits of icebergs. Logistics flights were necessary for unusual aircraft maintenance. Post-season flights were made to retrieve parts and equipment from Gander and to close out all business transactions from the season. Table 2 shows aircraft utilization during the 1983 season.

U. S. Coast Guard C-130 aircraft, deployed from Coast Guard Air Station Elizabeth City, North Carolina, conducted the aerial ice reconnaissance. U. S. Coast Guard HU-25A aircraft, deployed from Coast Guard Air Station Cape Cod, Massachusetts, were used on a trial basis on one deployment. This medium-range jet aircraft was found to be cheaper to operate and more comfortable than the C-130, but was incapable of conducting an extensive search of a large area and was not considered as reliable as the C-130 in poor flying conditions generally encountered in the Ice Patrol area. Both aircraft operated from Gander, Newfoundland.

Table 2

Aerial Ice Reconnaissance From 1 October 1982 to 30 September 1983

Ice Reconnaissance Flights	Number of Flights	Number of Hours Flown
Pre-season	12	62.5
In-season	103	621.0
Post-season	2	13.5
Total	117	697.0

Note: In-season ICERECDET flights include transit and logistics flights to and from Gander during the Ice Patrol season. There were 73 sorties dedicated solely to ice reconnaissance, with a total of 427.9 flight hours. They are summarized as follows:

Month	Ice Recon Flights
FEB	2
MAR	9
APR	7
MAY	13
JUN	12
JUL	20
AUG	10
Totals	73

U. S. Coast Guard Communications Station Boston, Massachusetts, NMF/NIK, was the primary radio station used for the transmission of the daily ice bulletins and facsimile charts after preparation by the Ice Patrol office in New York. Other transmitting stations included Canadian Coast Guard Radio Station St. John's/VON, Canadian Forces Radio Station Mill Cove/CFH, and U. S. Navy LCMP Broadcast Stations Norfolk/NAM, Thurso, Scotland, and Keflavik, Iceland.

Canadian Forces Station Mill Cove/CFH as well as AM Radio Station Bracknell/GFE, United Kingdom are radio facsimile broadcasting stations which used Ice Patrol limits in their broadcasts. Canadian Coast Guard Radio Station St. John's/VON provided special broadcasts.

The International Ice Patrol requested that all ships transiting the area of the Grand Banks report ice sightings, weather, and sea surface temperatures via U. S. Coast Guard Communications Station Boston, NMF/NIK. Response to this request is shown in Table 3 and Appendix A lists all contributors. Commander, International Ice Patrol extends a sincere thank you to all stations and ships which contributed.

Table 3

Number of ships furnishing Sea Surface Temperature (SST) reports	80
Number of SST reports received	334
Number of ships furnishing ice reports	84
Number of ice reports received	148
First Ice Bulletin	220000Z FEB 83
Last Ice Bulletin	260000Z AUG 83
Number of Facsimile Charts transmitted	195

The Coast Guard acquired a new Side-Looking Airborne Radar (SLAR) in October 1982, which was used extensively during the 1983 season. It is a model AN/APS-135 manufactured by Motorola, Inc., and replaces their older AN/APS-94D which was used on Coast Guard C-130 aircraft. The AN/APS-135 is a vast improvement over the AN/APS-94D. It proved to be an excellent tool for the detection of sea ice and icebergs, especially in low visibility conditions. In past years, the success of Ice Patrol reconnaissance flights were dependent upon good visibility in the search area. The new SLAR allowed the plane crew to search a certain area, regardless of the visibility conditions. The results from the SLAR were not as reliable as a good visual search due to the inability to positively identify and describe icebergs detected. But the weather conditions in Newfoundland and the Grand Banks are usually poor, forcing an aircraft without SLAR to remain on the ground twice as often, awaiting good visibility. This is no longer necessary with the AN/APS-135 SLAR.

The AN/APS-135 was first tested for use in iceberg detection during the pre-season deployment in January 1983. The International Ice Patrol detected a large amount of sea ice and icebergs in the Grand Banks area on this deployment, bringing the opening of the 1983 season in February 1983, earlier than normal. SLAR testing to determine optimum range and altitude for berg detection was scheduled for February, but these plans had to be cancelled in order to fly actual patrols to determine the limits of all known ice. Based on the information provided by Motorola, Inc. and preliminary operational testing, the optimum aircraft search altitude for SLAR was found to be 8000-10000 feet. A range of 27 miles either side of the aircraft appeared to be optimal for detection accuracy. It must be pointed out that IIP was unable to obtain any ground truth information on SLAR contact types and sizes detected by the SLAR. Visual confirmation of contacts was made from the aircraft whenever possible and some ground truthing of small boats and ships had been done in warmer waters. Based on these comparisons, SLAR operators analyzed contacts on the SLAR film to differentiate ships from bergs and estimate iceberg sizes.

The addition of the AN/APS-135 SLAR led Commander, International Ice Patrol (CIIP) to alter the normal routine of patrols. On a clear day the optimum altitude for a visual search is 2000 feet. The SLAR, however, works best at

8000 feet. Consequently, a SLAR-dedicated patrol sacrifices visual reliability, provided the weather is good (a rarity over the Grand Banks). The SLAR's optimal range for iceberg detection is 27 miles either side of the aircraft, which is better than the range on a visual search. Based on these factors, a standard altitude of 8000 feet and search track spacing of 25 miles was used for flight planning. The SLAR film has latitude and longitude grids automatically printed on it, enabling the operator to obtain very accurate positions of objects. The all-weather capability of the SLAR ensured that IIP could fly more patrols during a given period of time (barring any mechanical problems). In past years, an Ice Reconnaissance Detachment (ICERECDET) crew was kept in Newfoundland at all times during the season. Half their time was spent on the ground due to poor weather conditions. During the 1983 season, CIIP decided that this was no longer necessary. ICERECDET crews were deployed for one week at a time, every two weeks. While they were deployed, they flew every day, provided no aircraft problems or severe weather conditions (thunderstorms, blizzards, etc.) developed.

Comparing the 1983 and 1982 seasons, even though the 1983 ICERECDET crews spent about half as much time in Newfoundland, the number of reconnaissance patrols and flight hours flown were nearly the same. During 1983, 73 reconnaissance patrols were flown for a total of 427.9 hours, while during 1982, 79 reconnaissance patrols were flown for a total of 396 hours. This new one week patrol routine freed the aircraft and crew for other missions and cut costs without decreasing the number of hours spent on patrol. This routine did call for a "tight" schedule and optimum use of aircraft time while it was deployed. There was little leeway for down time if aircraft mechanical problems were to develop and there was little CIIP could do to investigate unusual berg sightings by ships if no aircraft were deployed. Fortunately, these problems were rare. Several times, the week-long patrols had to be extended (usually to 10 days) because of the large number of bergs in the area. It was impossible for the aircraft to adequately search the entire area in a week's time. But, 1983 was an unusually heavy year for berg activity and it remains to be seen if this same problem would develop during a season of "average" berg activity.

Overall, the addition of the AN/APS-135 SLAR was a welcome aid to Ice Patrol searches. It reduced dependency on good weather for flying patrols and allowed flight crews to return and perform post-flight analysis on the SLAR film.

Once sufficient ground truthing of the SLAR is conducted and correlations are drawn between SLAR film contact sizes and the actual sizes of objects, the information IIP obtains from the SLAR will be more reliable.

Environmental Conditions, 1983 Season

Air temperatures over Labrador and eastern Newfoundland show various departures from climatological averages (Table 4). The four weather stations listed (Hopedale, Labrador (55°25'N, 60°10'W); Goose, Labrador (53°25'N, 60°20'W); Gander, Newfoundland (48°55'N, 54°35'W); St. John's, Newfoundland (47°35'N, 52°40'W)) were selected to give a cross section of weather trends throughout the province. Generally, the temperatures during the fall of 1982 and winter of 1983 averaged below normal at the stations. It wasn't until March that temperatures started to return to normal. April and May were warmer than usual in Newfoundland with temperatures fluctuating in Labrador. For the early summer months, temperatures averaged near normal before falling below normal in August. September temperatures were relatively normal.

Table 4

Environmental Conditions for 1983 International Ice Patrol Season

	Station	TEMP° C Monthly Mean	TEMP° C Diff. from Mean	Total Precipitation (mm)	% of Normal Precipitation	% of Normal Snowfall
OCT 1982	Hopedale	.6	-1.8	25.1	40	82
	Goose	.8	-2.4	30.8	43	31
	Gander	4.2	-2.1	131.0	137	137
	St. Johns	5.4	-1.7	165.4	119	27
NOV	Hopedale	-4.5	-1.3	37.3	65	78
	Goose	-4.6	-1.1	51.2	73	85
	Gander	1.8	-.1	103.8	97	114
	St. Johns	3.6	.1	101.5	63	62
DEC	Hopedale	-15.7	-5.0	62.9	111	121
	Goose	-17.3	-5.1	99.8	146	199
	Gander	-4.0	-.7	137.4	140	180
	St. Johns	-1.2	0.0	158.6	95	31
JAN 1983	Hopedale	-20.6	-4.8	40.4	65	63
	Goose	-19.1	-2.9	37.4	54	88
	Gander	-6.0	0.0	142.6	152	141
	St. Johns	-2.8	.9	150.1	104	81
FEB	Hopedale	-19.6	-4.5	97.1	194	218
	Goose	-18.3	-4.0	65.0	108	157
	Gander	-7.5	-1.3	148.4	147	208
	St. Johns	-4.2	-.1	146.2	94	93

* No snowfall recorded during this month

** Data for this table is taken from information published by the Canadian Climate Centre, Atmospheric Environment Service, Downsview, Ontario, Canada. In June 1983, they changed their publication format and the percent of Normal Snowfall was no longer included.

	Station	TEMP° C Monthly Mean	TEMP° C Diff. from Mean	Total Precipitation (mm)	% of Normal Precipitation	% of Normal Snowfall
	Hopedale	-12.8	-2.3	146.3	264	287
MAR	Goose	-9.9	-1.6	122.8	177	226
	Gander	-2.7	.8	119.0	123	117
	St. Johns	-1.2	1.1	176.6	133	14
	Hopedale	-2.4	2.5	49.3	106	59
APR	Goose	.9	2.6	67.5	125	66
	Gander	5.0	4.2	45.8	54	19
	St. Johns	3.8	2.7	136.4	120	5
	Hopedale	.7	-.7	22.3	44	59
MAY	Goose	4.6	-.4	62.6	98	164
	Gander	6.8	.6	76.5	109	9
	St. Johns	7.2	1.8	87.2	86	*
	Hopedale	7.2	.8	37.7	59	**
JUN	Goose	11.4	.1	86.8	93	**
	Gander	12.6	.8	45.8	57	**
	St. Johns	11.5	.6	85.8	100	**
	Hopedale	11.1	.6	138.5	164	**
JUL	Goose	15.8	0.0	149.7	142	**
	Gander	16.8	.3	138.2	200	**
	St. Johns	16.5	1.0	121.4	161	**
	Hopedale	10.5	-.3	40.3	59	**
AUG	Goose	13.6	-.7	57.2	55	**
	Gander	14.1	-1.5	115.4	160	**
	St. Johns	14.0	-1.3	140.5	116	**
	Hopedale	6.4	-.8	113.2	120	**
SEP	Goose	9.3	.2	68.2	77	**
	Gander	11.7	.3	67.0	83	**
	St. Johns	11.9	.3	189.9	163	**

* No snowfall recorded during this month

** Data for this table is taken from information published by the Canadian Climate Centre, Atmospheric Environment Service, Downsview, Ontario, Canada. In June 1983, they changed their publication format and the percent of Normal Snowfall was no longer included.

Ice Conditions, 1983 Season

October - November 1982

No sea ice formed south of 58°N during the months of October and November. Figures 1 and 2 illustrate the growth of sea ice during these months. By the end of November, ice had extended down to the northern tip of Labrador, surrounding Resolution Island and closing in Frobisher Bay, with some ice forming along the coastal areas of Ungava Bay. Commander, International Ice Patrol (CIIP) did not receive any reports of icebergs off the coast of Newfoundland or in the Grand Banks region.

December 1982

The migration of icebergs into the Grand Banks region started earlier than usual this ice season. CIIP began receiving reports of bergs crossing south of 49°N during the second week of this month. By 16 December, the IIP had 11 bergs south of 52°N on its computer plot. By the end of the month, a total of 12 bergs had been reported to CIIP, two of which had drifted south of 48°N. Sea ice conditions were also heavier than usual for this early in the winter. By 14 December, the sea ice edge extended as far south as Cape Charles, Labrador, threatening to close the Straits of Belle Isle sooner than normal (Figure 3).

January 1983

A total of 68 bergs were reported to CIIP this month, 9 of which drifted below 48°N. These reports prompted CIIP to fly the first Ice Patrol aerial reconnaissance flights of the 1983 season on 27 and 28 January. The sea ice edge continued to move south, with ice forming in the Straits of Belle Isle and along portions of the northeastern shores of Newfoundland (Figure 4).

February 1983

Ice Patrol reconnaissance flights were flown on 11-12, and 19-21 February. Icebergs were observed to be approaching the Grand Banks area. As a result of these flights, and iceberg reports IIP received from ships transiting the North Atlantic, the regular Ice Patrol season was opened on 22 February. Two more reconnaissance flights were flown at the end of the month. A total of 138 bergs were sighted during the month and 165 icebergs drifted below 48°N which included those icebergs originally sighted in January. By the end of the month, there were 75 bergs being carried on computer plot. Figures 13 and 14 show the concentrated iceberg conditions at the start of the 1983 season and the dispersed iceberg conditions at the end of the month. A large number of icebergs spread out over a large area is more dangerous to shipping because it is more difficult to locate a single iceberg than a concentrated group of them. Heavy sea ice which provides protection for the icebergs was found along Newfoundland's east coast as shown in Figure 5 and also caused numerous problems for ships.

March 1983

The sea ice continued to move south along the Newfoundland coast, extending to the southern shores of the Avalon Peninsula (Figure 6). This was much further south than normal, due in part to the below normal temperatures during this winter (Table 4). This pack-ice also extended eastward to 51°W, forcing three oil rigs to be moved off the Hibernia oil fields. The southern limit of all known ice also pushed south, extending below 42°N during the first half of the month, then receding north to 45°N by 30 March (Figures 15 and 16). There were 137 new icebergs sighted during the month with 124 bergs drifting south of 48°N. At the end of the month, 45 bergs remained on computer plot.

April 1983

The southern movement of the sea ice finally subsided this month but pack-ice concentrations remained heavy north of the Straits of Belle Isle and off the Labrador coast (Figure 7). Iceberg sightings increased during April. During the month, 373 bergs were sighted and 339 bergs drifted south of 48°N. The limits of all known ice moved south as the month progressed (Figures 17 and 18). By 30 April, the limits extended below 42°N again and 124 bergs remained on computer plot.

May 1983

The warm temperatures of April (see Table 4) helped to trigger the break-up of pack-ice concentrations east of Newfoundland. By 17 May, the ice edge had receded north of 50°N (Figure 8). As the sea ice broke up, the icebergs trapped in the pack were released and an increased flow of bergs south over the Grand Banks occurred (Figures 19 and 20). This month 586 new bergs were sighted with 465 bergs drifting south of 48°N. At the end of the month, 215 bergs remained on computer plot with the limit of all known ice extending south to 42°N.

June 1983

With above normal temperatures throughout the spring months, the sea ice continued to recede northward. By the middle of the month, there was no sea ice left south of 53°N (Figure 9). The concentration of bergs in the Grand Banks region remained high throughout the month as the bergs emerged from the melting pack ice and the limit of all known ice showed little movement northward (Figures 21 and 22). The number of new icebergs sighted this month dropped from the previous month to 292. A total of 168 bergs drifted south of 48°N. At the end of the month, 140 bergs remained on computer plot.

July 1983

Figure 10 illustrates the sea ice conditions on 12 July. A comparison of Figures 9 and 10 shows the rapid deterioration of the pack-ice during this period. The concentration of bergs in the Grand Banks region, on the other hand, showed no trend towards diminishing (Figures 23 and 24) although the southernmost limits moved northward from 41° to 44°N. A total of 407 bergs were sighted during the month, and 76 bergs drifted south of 48°N. Still, 110 bergs remained on computer plot on 31 July.

August 1983

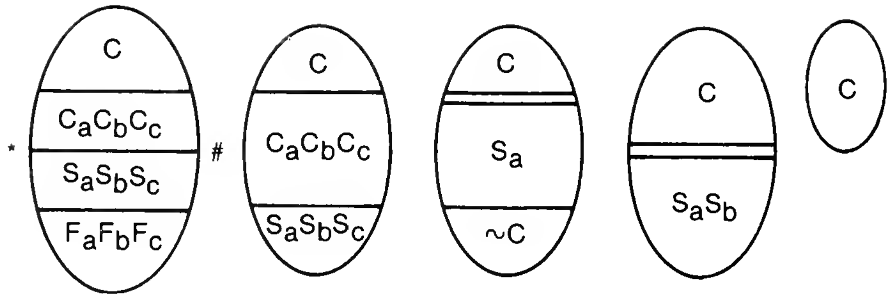
The southern limit of the sea ice had receded to nearly 60°N by the middle of the month (Figure 11) and most of the ice remaining south of 60°N was concentrated in belts and patches of thin, first year ice. The southern limit of icebergs continued to move northward to 48°N during the month (Figure 25). By 25 August only 13 bergs (Figure 26) remained on plot. A total of 58 bergs had been sighted during August and only 4 of these had drifted south of 48°N. Based on these facts and the lack of icebergs south of 48°N, Commander, International Ice Patrol declared the 1983 season officially closed on 25 August 1983.

September 1983

Although the 1983 season ended during August, CIIP continued to receive iceberg sighting reports into September and entered them onto their computer plot as post-season entries. A total of 10 bergs were sighted in the IIP area prior to 13 September. None of these bergs drifted south of 48°N and the computer plot was discontinued on 13 September. Also sea ice continued to deteriorate during the month (Figure 12), and by 20 September, all sea ice was north of Hudson Strait (62°N).

Table 5

Explanation of Sea Ice Symbology Used in Figures 1 - 12



C = Total ice concentration in the area in tenths.

$C_aC_bC_c$ = Concentration of thickest (C_a), 2nd thickest (C_b), and 3rd thickest (C_c).

$S_aS_bS_c$ = Stage of development of thickest (S_a), 2nd thickest (S_b), and 3rd thickest (S_c).

$\sim C$ = Concentration of ice within areas of strips and patches.

$F_aF_bF_c$ = Floe size of thickest (F_a), 2nd thickest (F_b), and 3rd thickest (F_c).

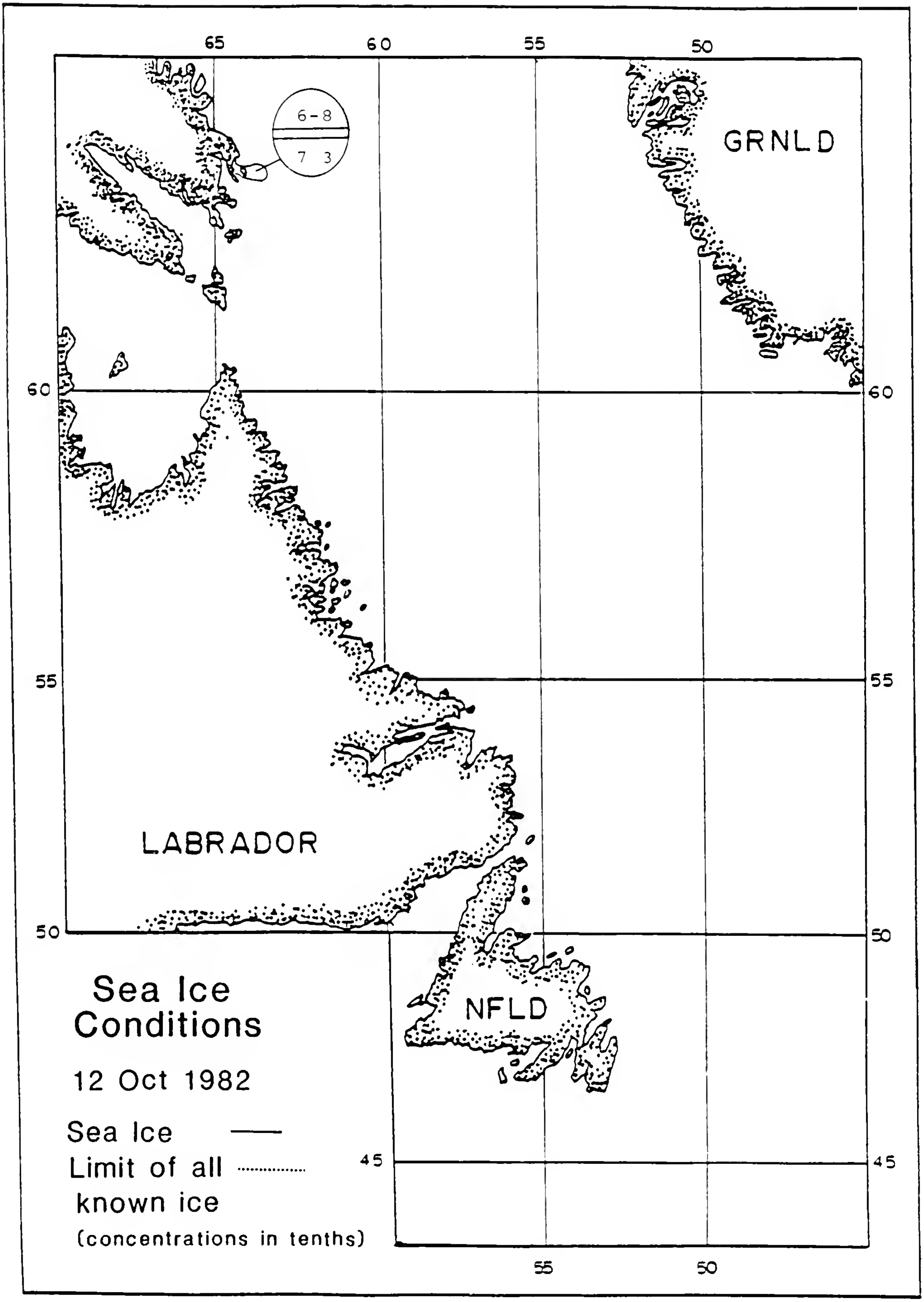
Stage of Development

0	No stage of development
1	New Ice
2	Nilas, ice rind
3	Young ice
4	Grey ice
5	Grey-white ice
6	First year ice
7	Thin first year ice
8	Thin first year ice 30-50 cm
9	Thin first year ice 50-70 cm
1.	Medium first year ice
4.	Thick first year ice
7.	Old ice
8.	Second year ice
9.	Multi-year
▲	Icebergs
*	A trace of ice thicker than S_a
#	Fourth type if $C_aC_bC_c$ do not add up to C

Floe Sizes

0	Pancake ice
1	Brash, small ice cake
2	Ice cake
3	Small floe
4	Medium floe
5	Big floe
6	Vast floe
7	Giant floe
8	Growlers and floebergs
9	Icebergs
/	Undetermined or unknown

Figure 1


65
60
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7 3
GRNLD
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LABRADOR
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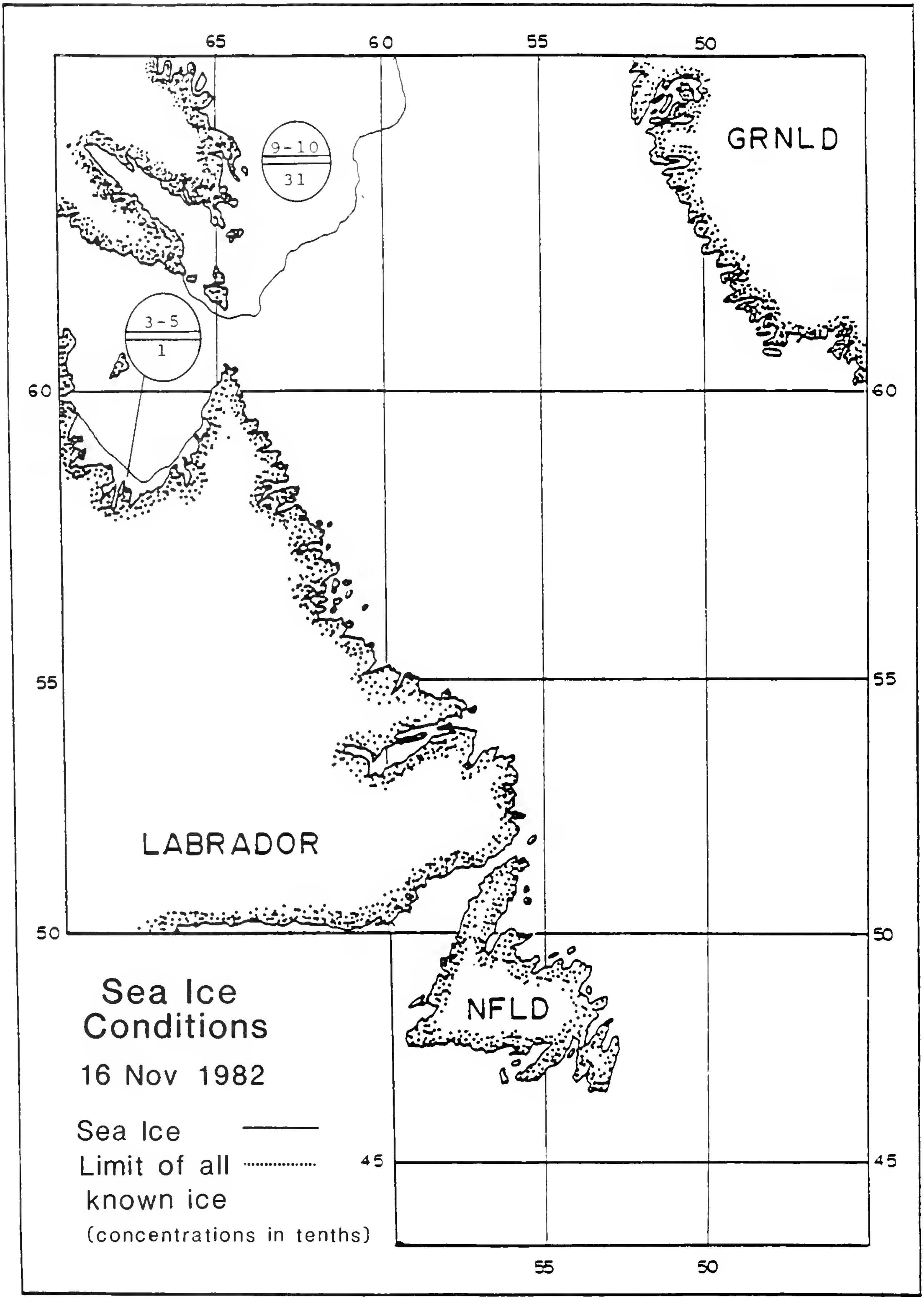
NFLD
45
Sea Ice Conditions
12 Oct 1982
Sea Ice
Limit of all known ice
(concentrations in tenths)

Figure 2



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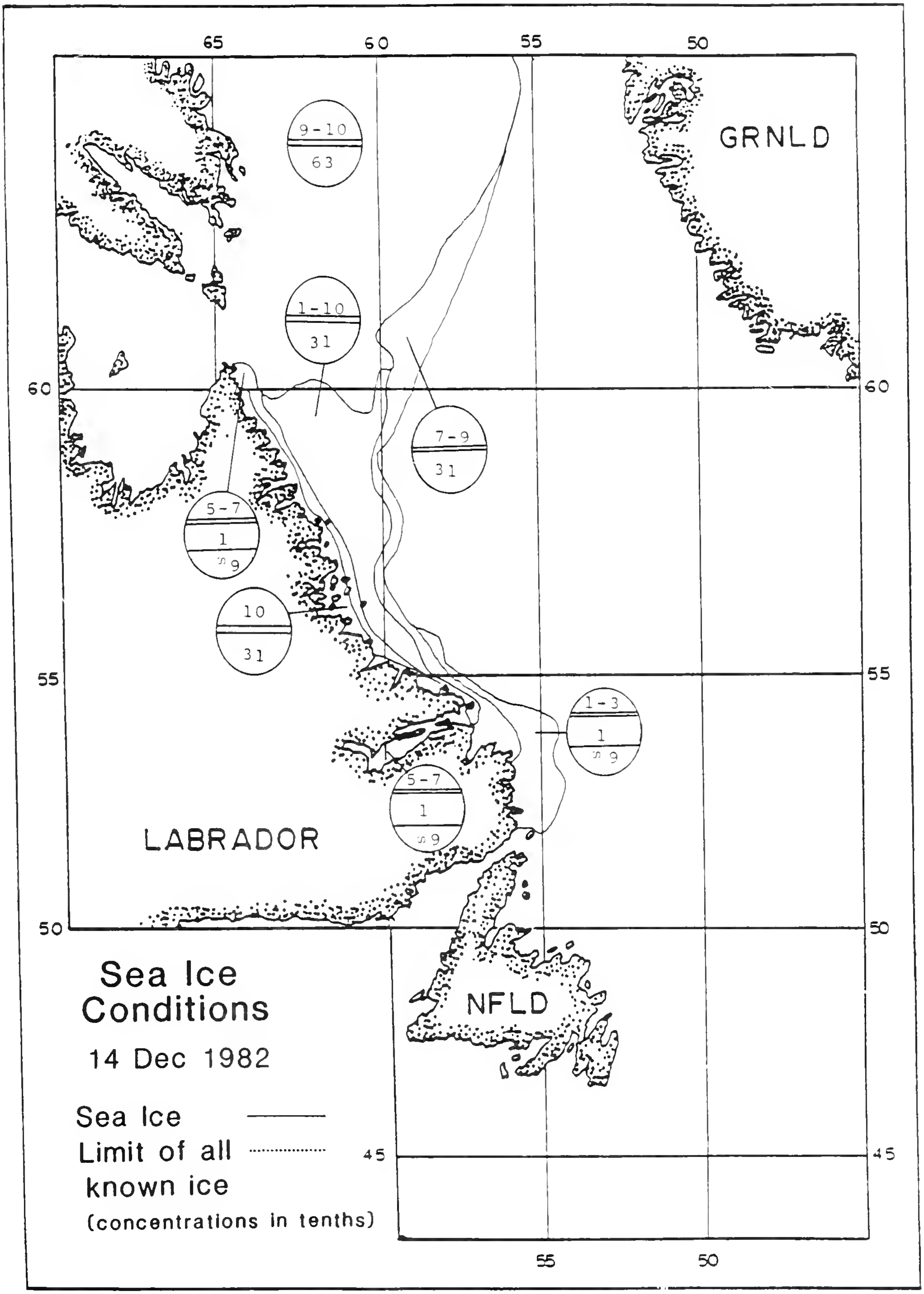
Sea Ice
Conditions
16 Nov 1982
Sea Ice
Limit of all
known ice
(concentrations in tenths)
45

Figure 3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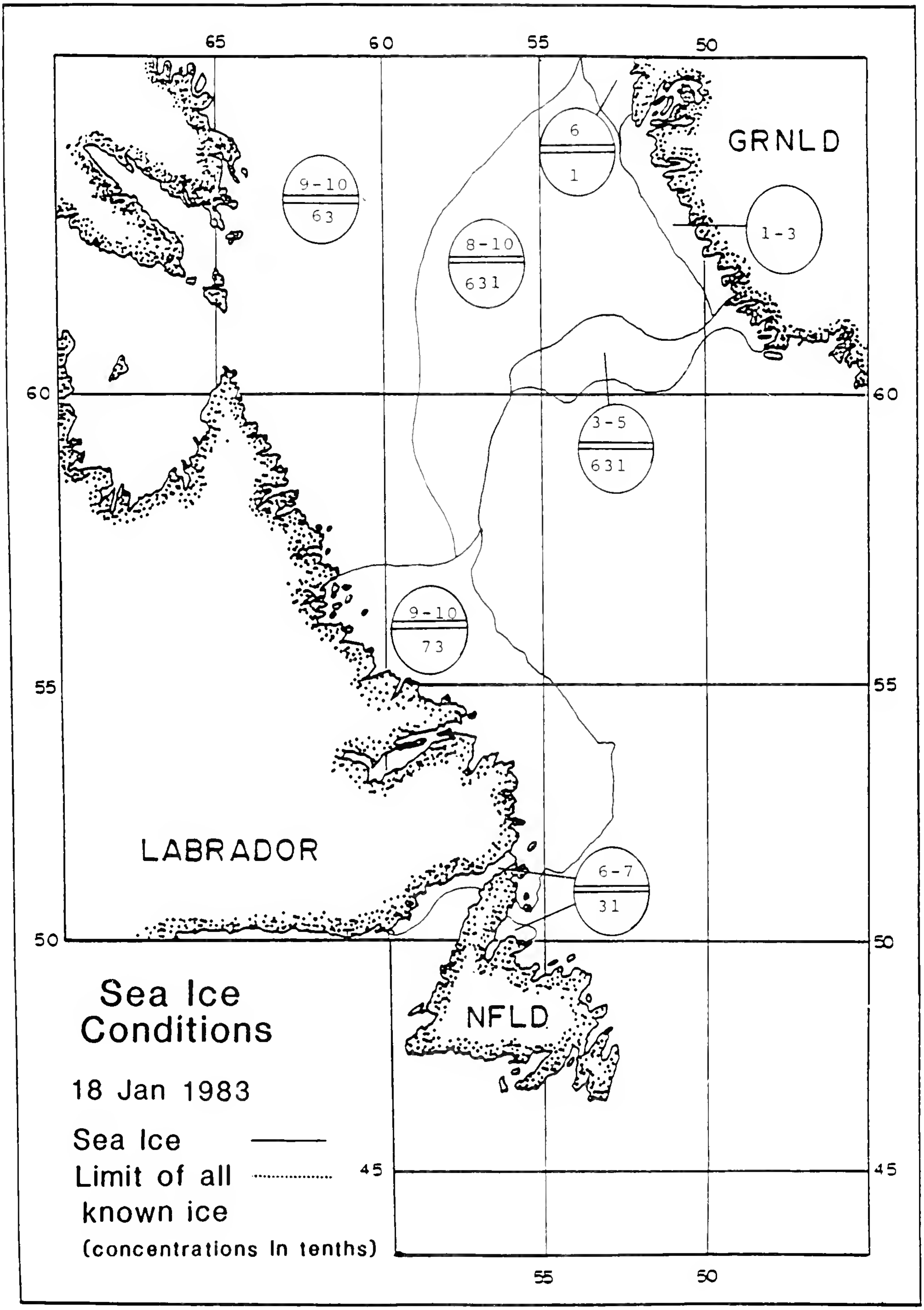
14 Dec 1982
Sea Ice
Limit of all
known ice
(concentrations in tenths)

Figure 4



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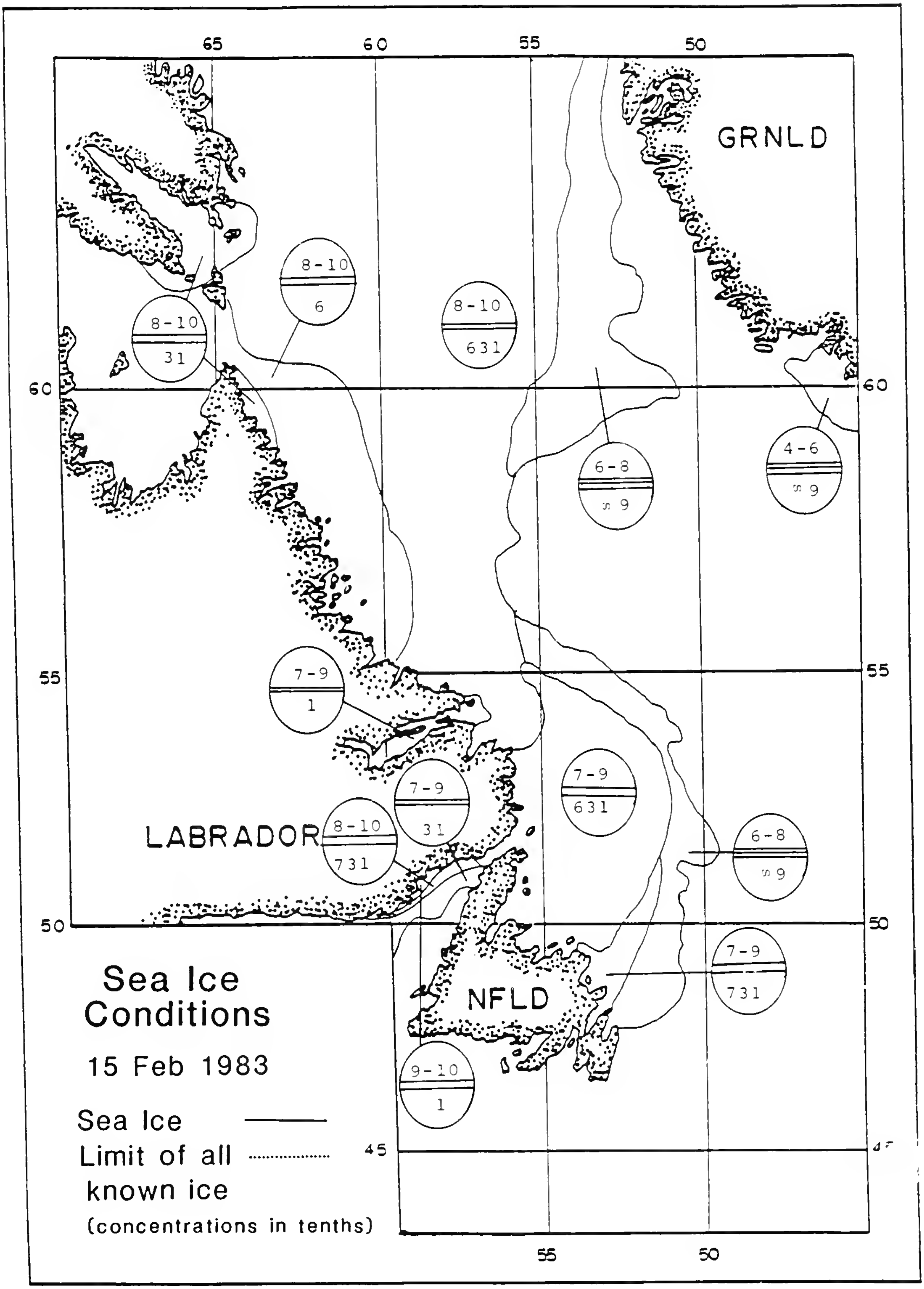
50
GRNLD
6
1
9-10
63
1-3
8-10
631
60
60
3-5
631
9-10
73
55
55
LABRADOR
6-7
31
50
50
Sea Ice Conditions
NFLD
18 Jan 1983
Sea Ice
Limit of all known ice
45
45
(concentrations in tenths)
55
50

Figure 5



65
60
55
50
GRNLD
8-10
6
8-10
31
8-10
631
60
6-8
9
4-6
9
55
7-9
1
7-9
31
7-9
631
LABRADOR
8-10
731
6-8
9
50
7-9
731
NFLD
9-10
1
45
Sea Ice Conditions
15 Feb 1983
Sea Ice
Limit of all known ice
(concentrations in tenths)

Figure 6

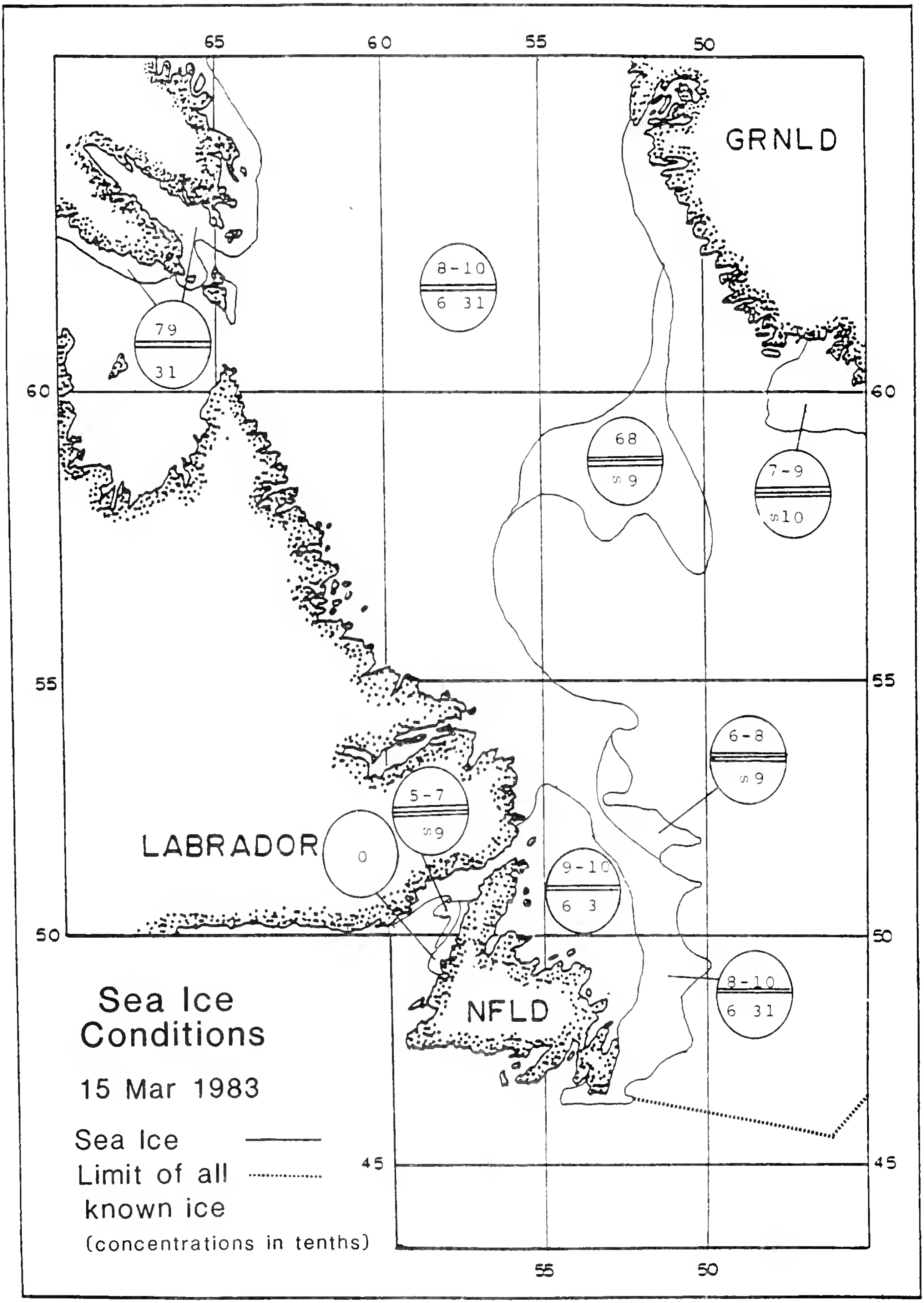

65
60
55
50
GRNLD
8-10
6 31
79
31
60
68
9
7-9
10
55
6-8
9
5-7
9
LABRADOR
0
9-10
6 3
50
8-10
6 31
NFLD
Sea Ice Conditions
15 Mar 1983
Sea Ice
Limit of all known ice
(concentrations in tenths)
45

Figure 7

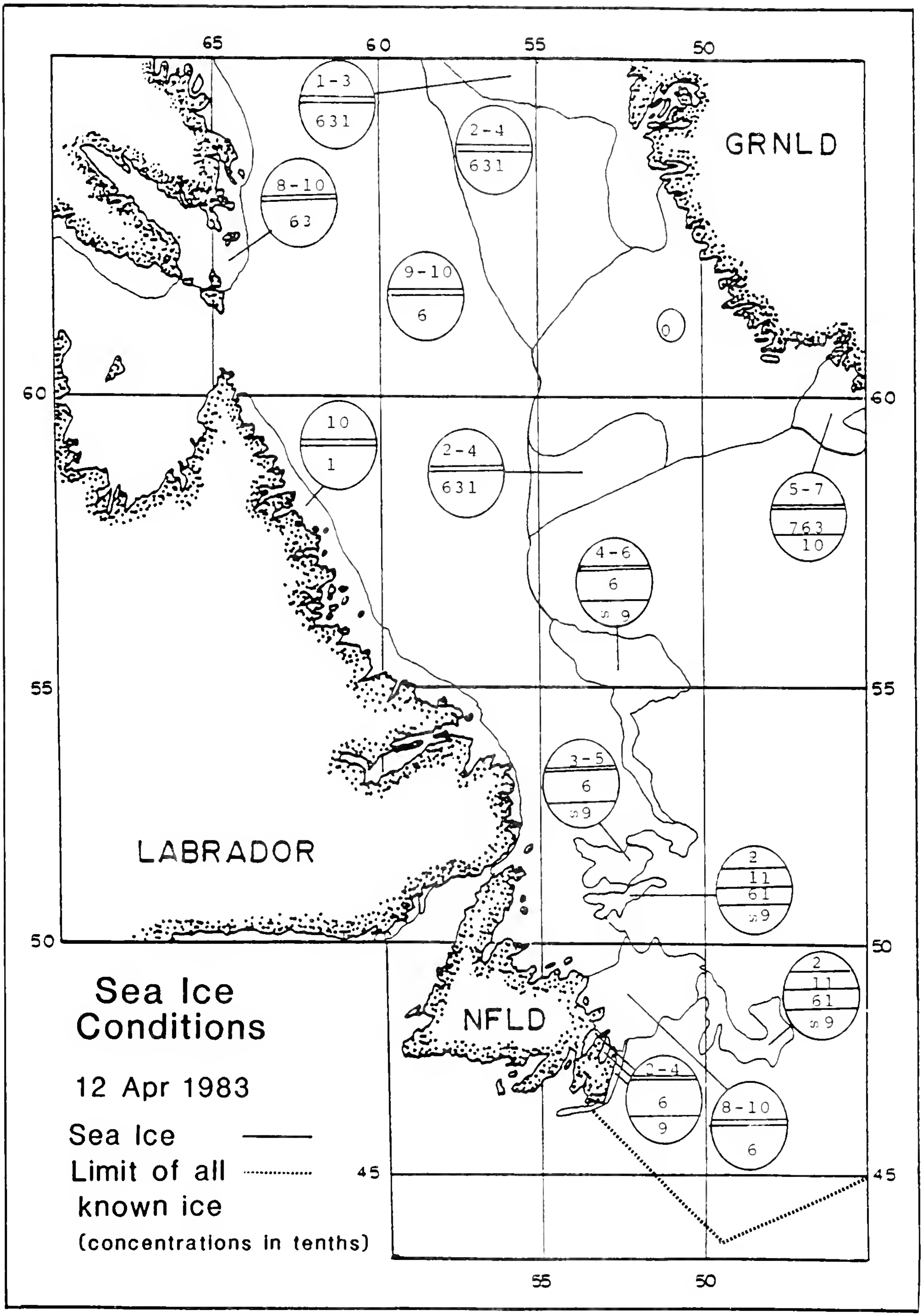
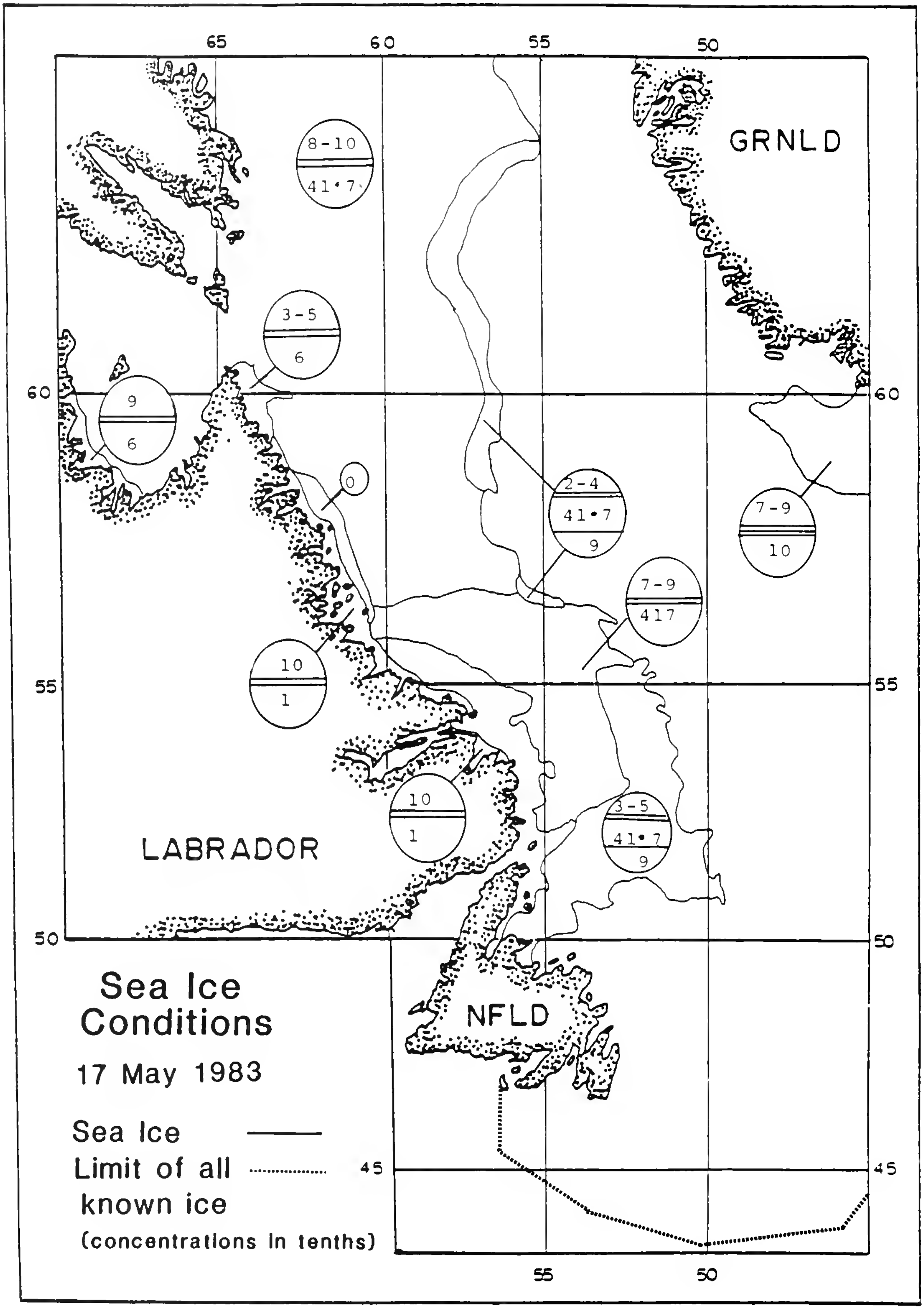
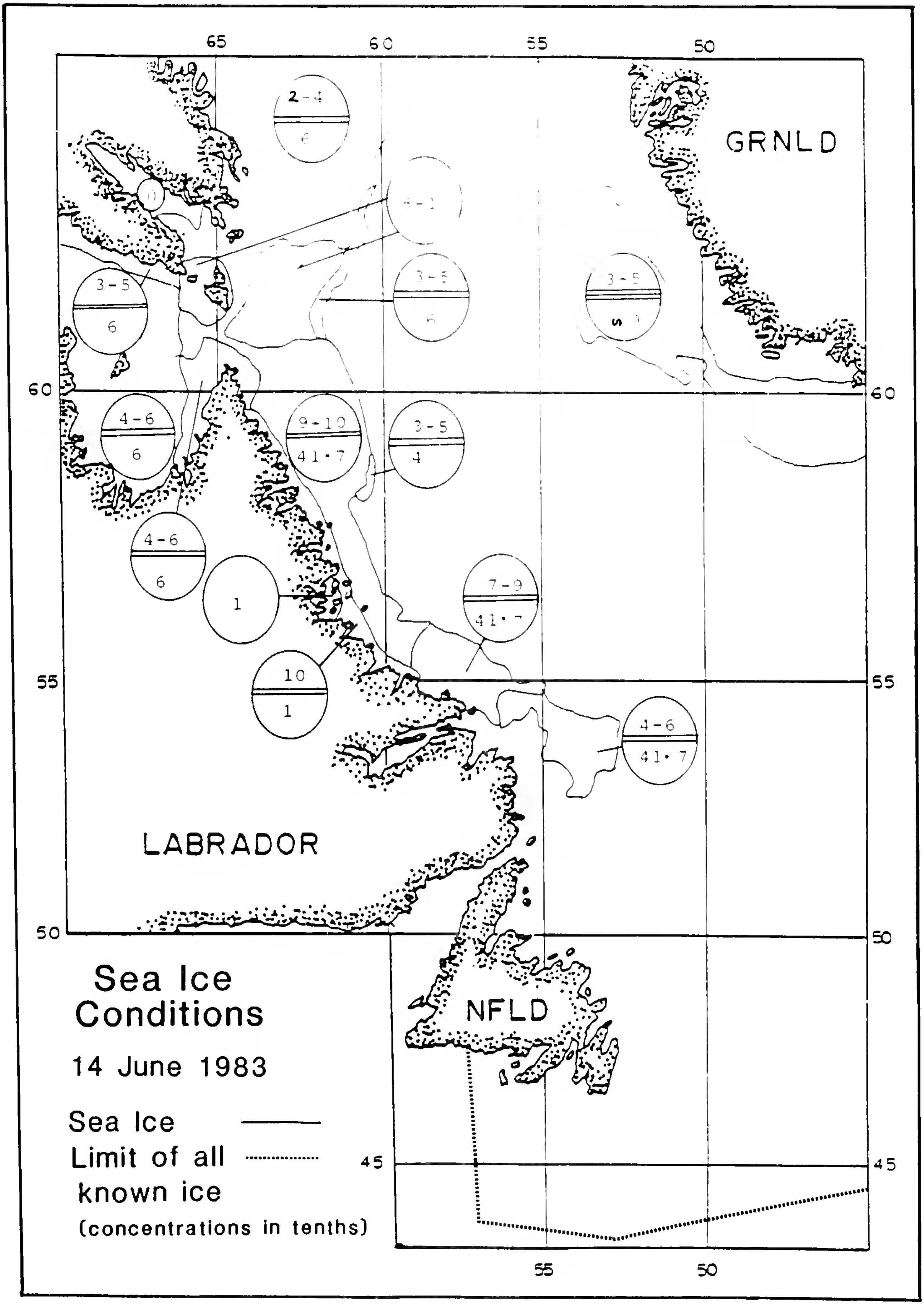

65
60
55
50
GRNLD
LABRADOR
NFLD
1-3
631
2-4
631
8-10
63
9-10
6
0
10
1
2-4
631
5-7
763
10
4-6
6
9
3-5
6
9
2
11
61
9
2
11
61
9
2-4
6
9
8-10
6
45
Sea Ice Conditions
12 Apr 1983
Sea Ice
Limit of all known ice
(concentrations in tenths)

Figure 8



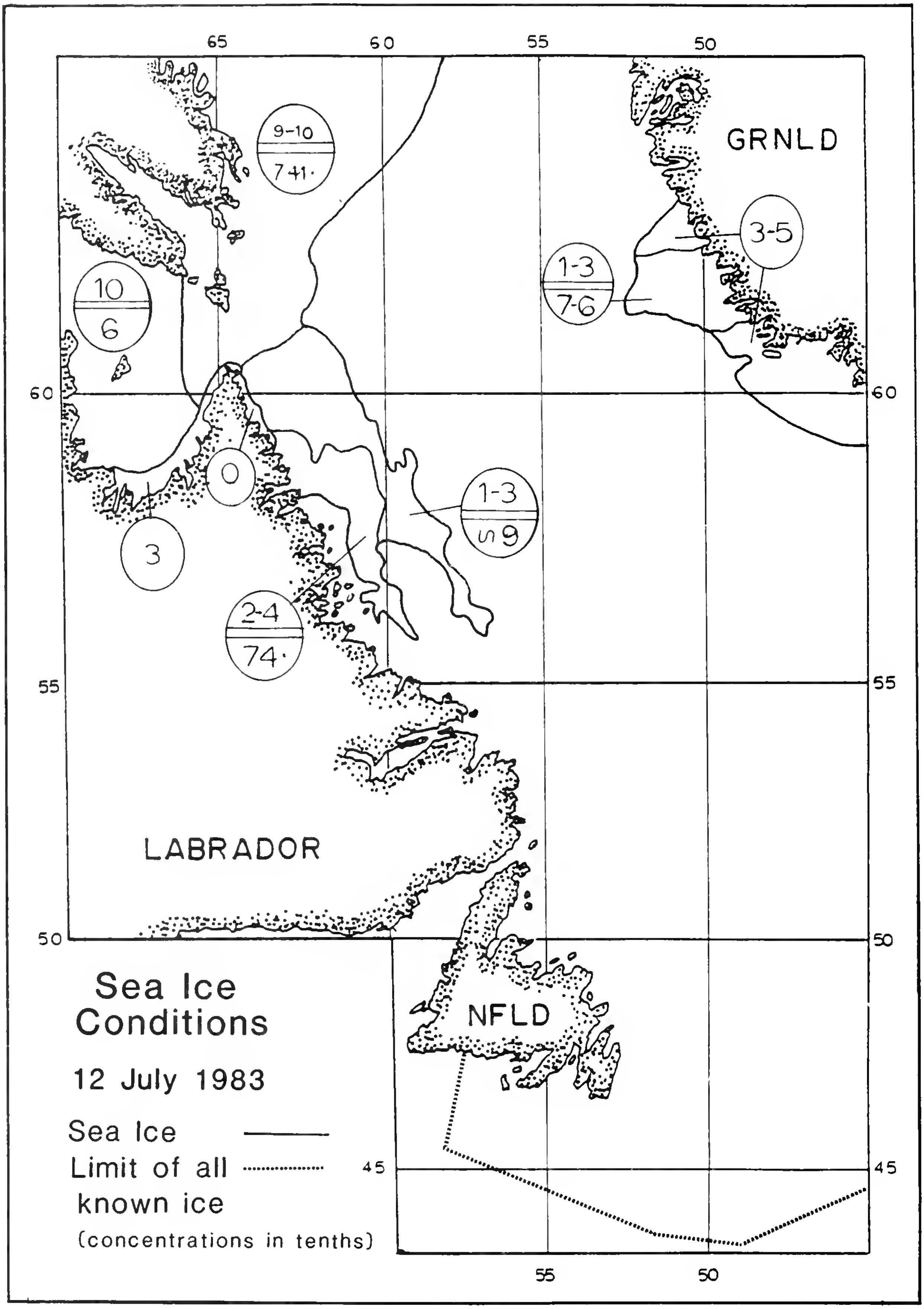
65
60
55
50
GRNLD
8-10
41•7
3-5
6
9
6
0
2-4
41•7
9
7-9
10
7-9
417
10
1
10
1
3-5
41•7
9
LABRADOR
NFLD
60
55
50
45
Sea Ice Conditions
17 May 1983
Sea Ice
Limit of all known ice
(concentrations in tenths)

Figure 9



65
60
55
50
GRNLD
LABRADOR
NFLD
Sea Ice
Conditions
14 June 1983
Sea Ice
Limit of all
known ice
(concentrations in tenths)

Figure 10



65
60
55
50
60
55
50
45
GRNLD
LABRADOR
NFLD
9-10
7 4 1 ·
10
6
3-5
1-3
7 6
0
3
1-3
5 9
2-4
7 4 ·
Sea Ice
Conditions
12 July 1983
Sea Ice
Limit of all
known ice
(concentrations in tenths)

Figure 11

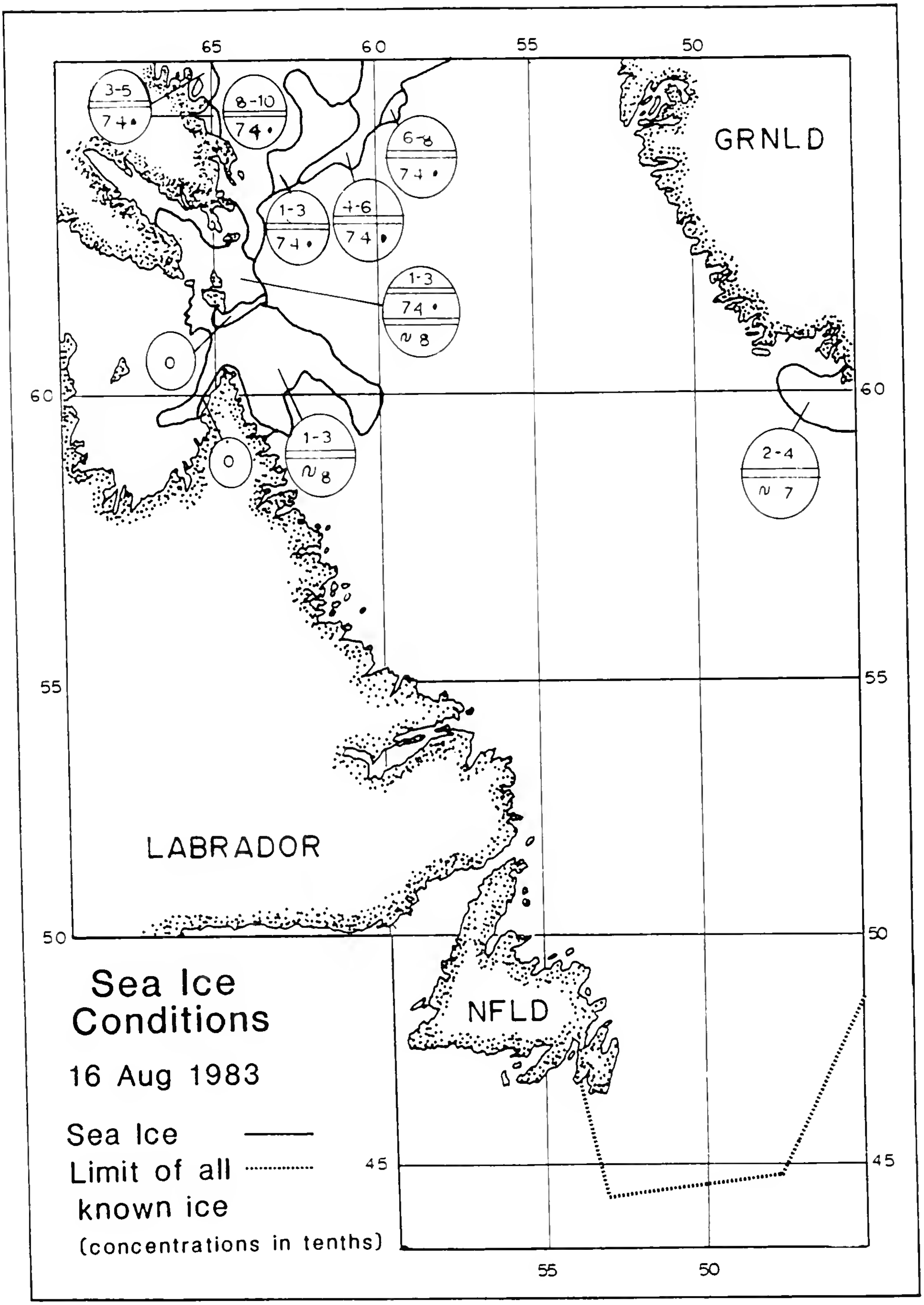

65
60
55
50
3-5
74•
8-10
74•
6-8
74•
1-3
74•
4-6
74•
1-3
74•
≈8
0
0
1-3
≈8
2-4
≈7
GRNLD
60
55
50
45
LABRADOR
NFLD
Sea Ice Conditions
16 Aug 1983
Sea Ice
Limit of all known ice
(concentrations in tenths)

Figure 12

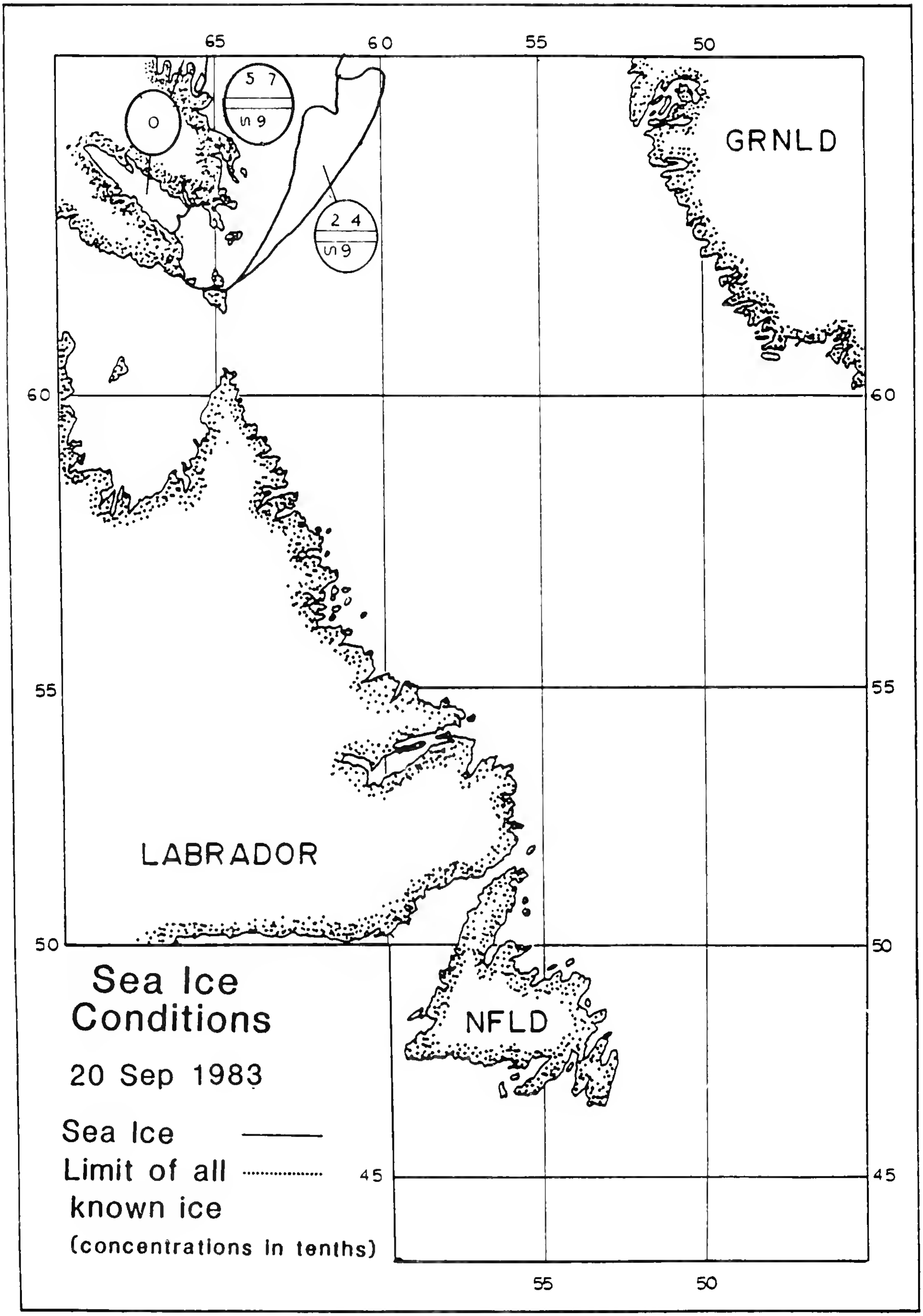

65
60
55
50
5 7
9
0
2 4
9
GRNLD
60
60
55
55
LABRADOR
50
50
NFLD
Sea Ice
Conditions
20 Sep 1983
Sea Ice
Limit of all
known ice
(concentrations in tenths)
45
45
55
50

Figure 13

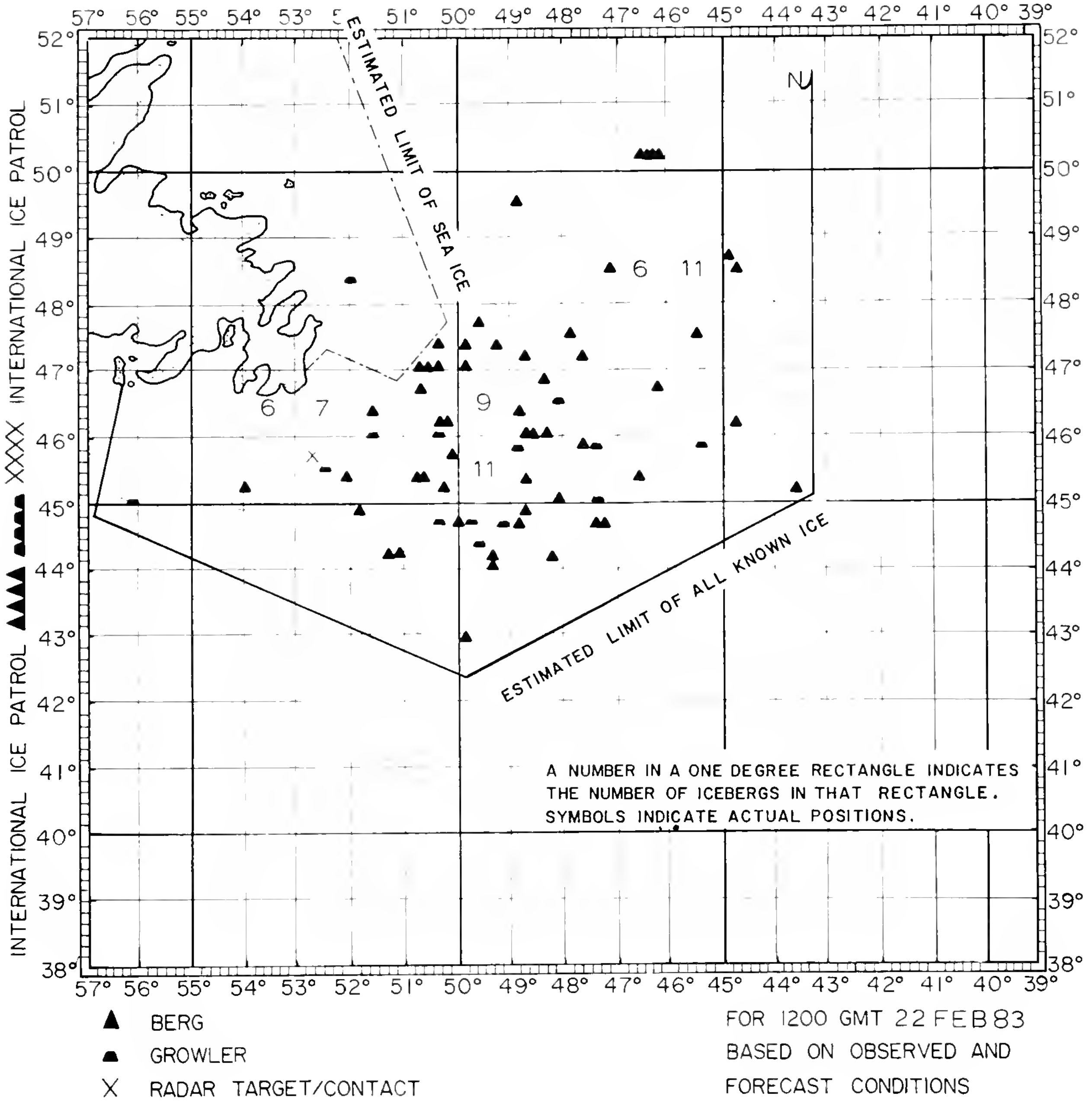
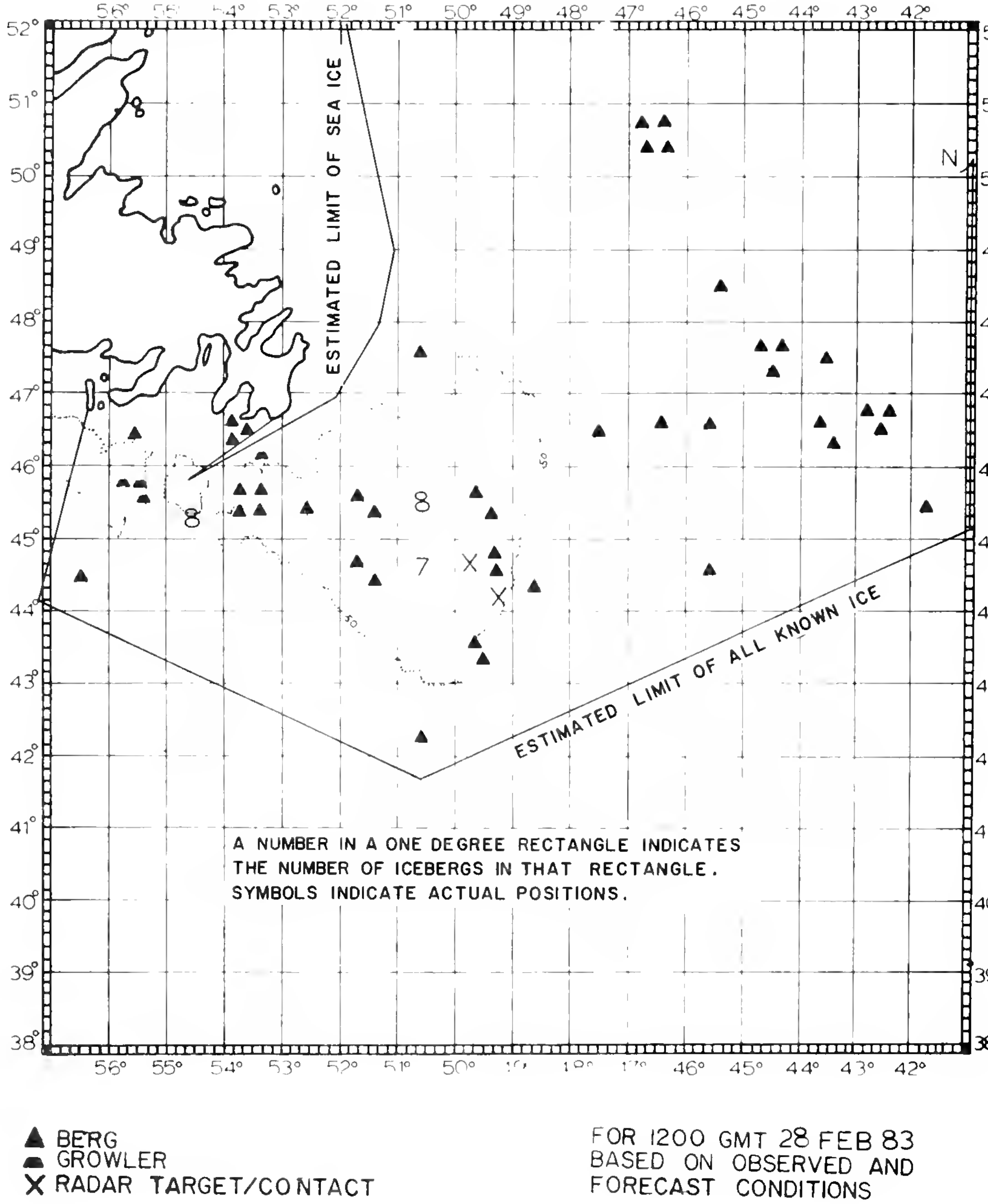
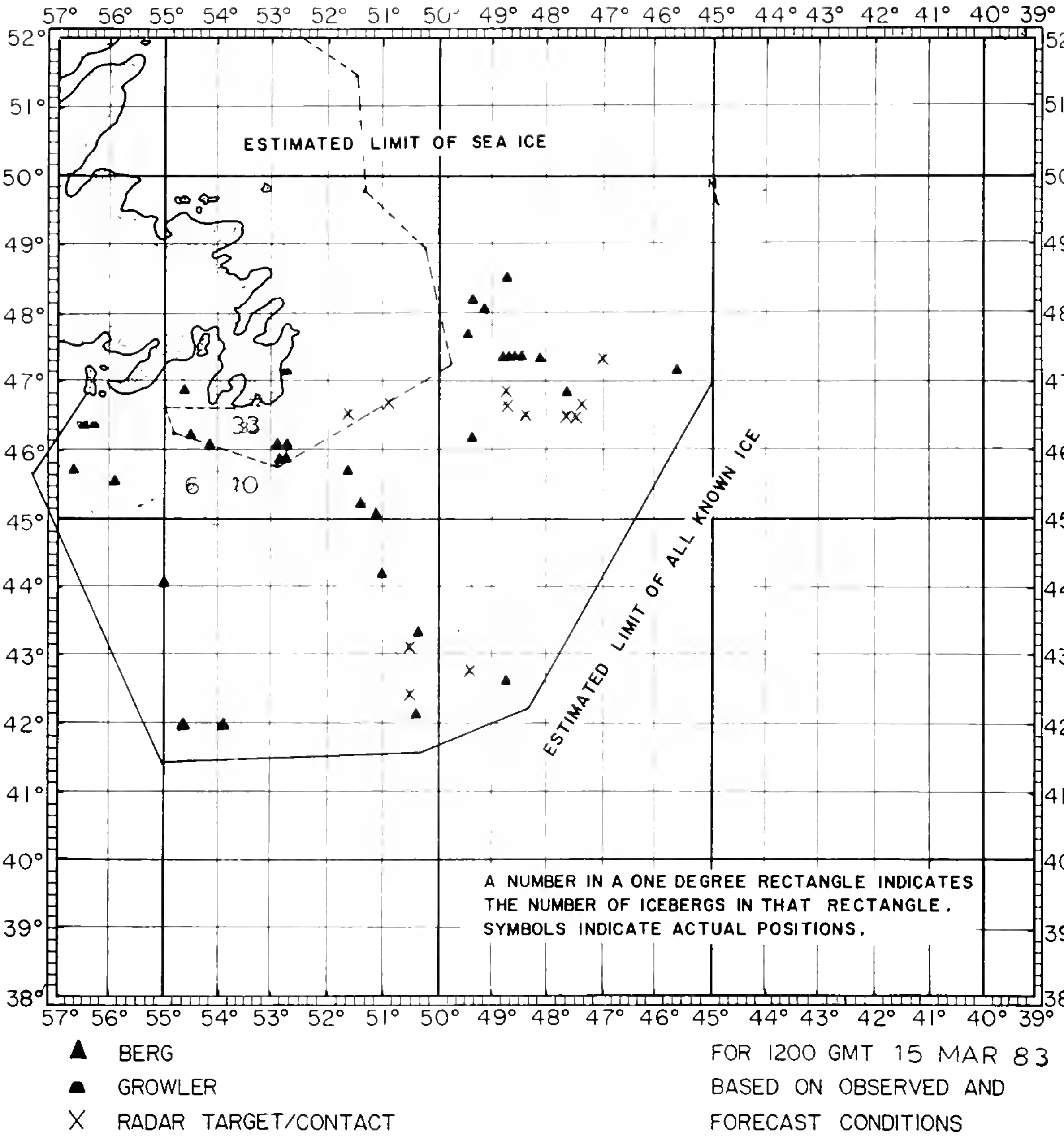

INTERNATIONAL ICE PATROL XXXX INTERNATIONAL ICE PATROL
57° 56° 55° 54° 53° 52° 51° 50° 49° 48° 47° 46° 45° 44° 43° 42° 41° 40° 39°
52° 51° 50° 49° 48° 47° 46° 45° 44° 43° 42° 41° 40° 39° 38°
ESTIMATED LIMIT OF SEA ICE
ESTIMATED LIMIT OF ALL KNOWN ICE
6 11
6 7 9 11
A NUMBER IN A ONE DEGREE RECTANGLE INDICATES THE NUMBER OF ICEBERGS IN THAT RECTANGLE. SYMBOLS INDICATE ACTUAL POSITIONS.
BERG
GROWLER
RADAR TARGET/CONTACT
FOR 1200 GMT 22 FEB 83
BASED ON OBSERVED AND FORECAST CONDITIONS

Figure 14



ESTIMATED LIMIT OF SEA ICE
ESTIMATED LIMIT OF ALL KNOWN ICE
A NUMBER IN A ONE DEGREE RECTANGLE INDICATES THE NUMBER OF ICEBERGS IN THAT RECTANGLE. SYMBOLS INDICATE ACTUAL POSITIONS.
8
8
7
N
BERG
GROWLER
X RADAR TARGET/CONTACT
FOR 1200 GMT 28 FEB 83
BASED ON OBSERVED AND
FORECAST CONDITIONS

Figure 15



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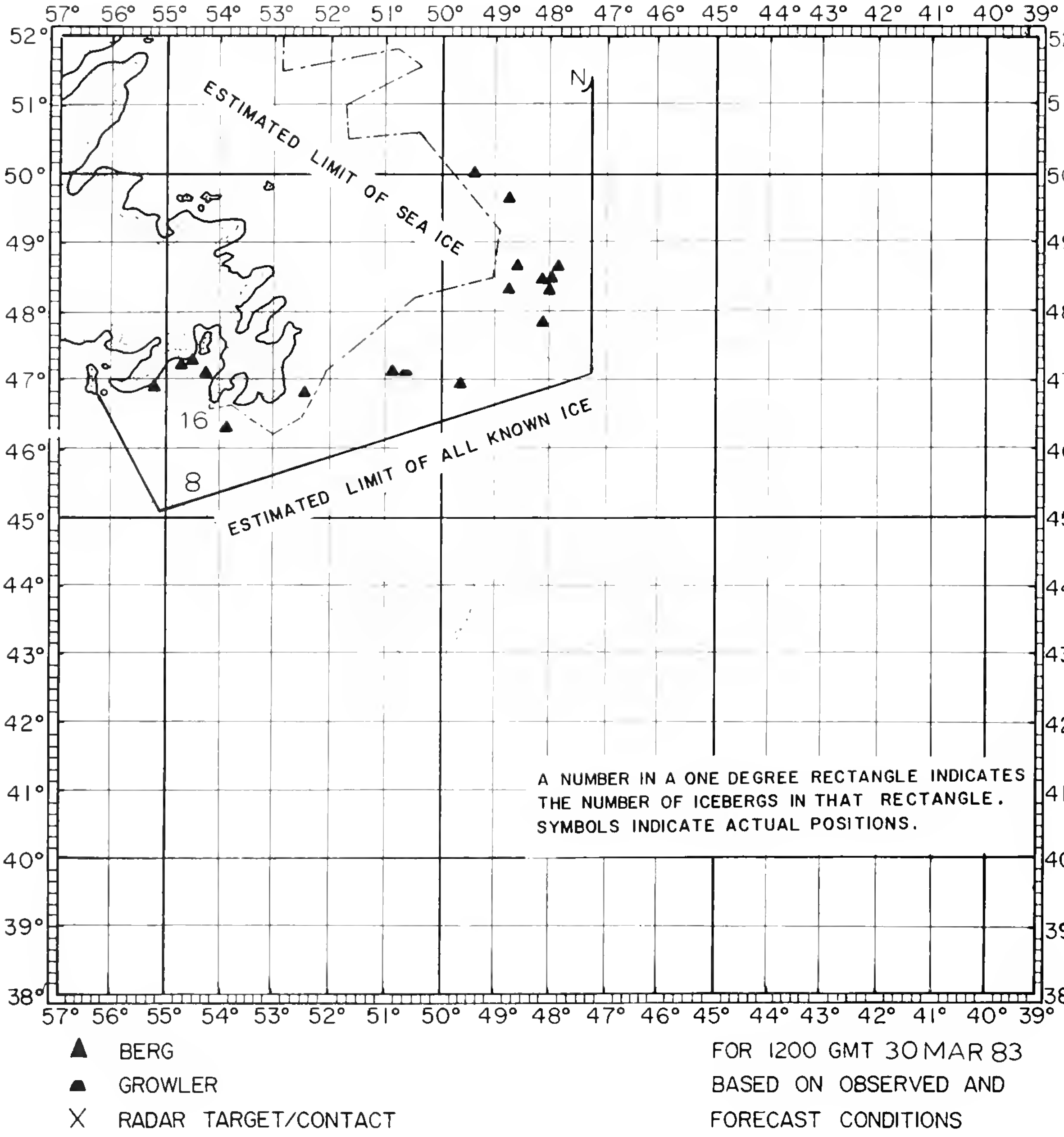
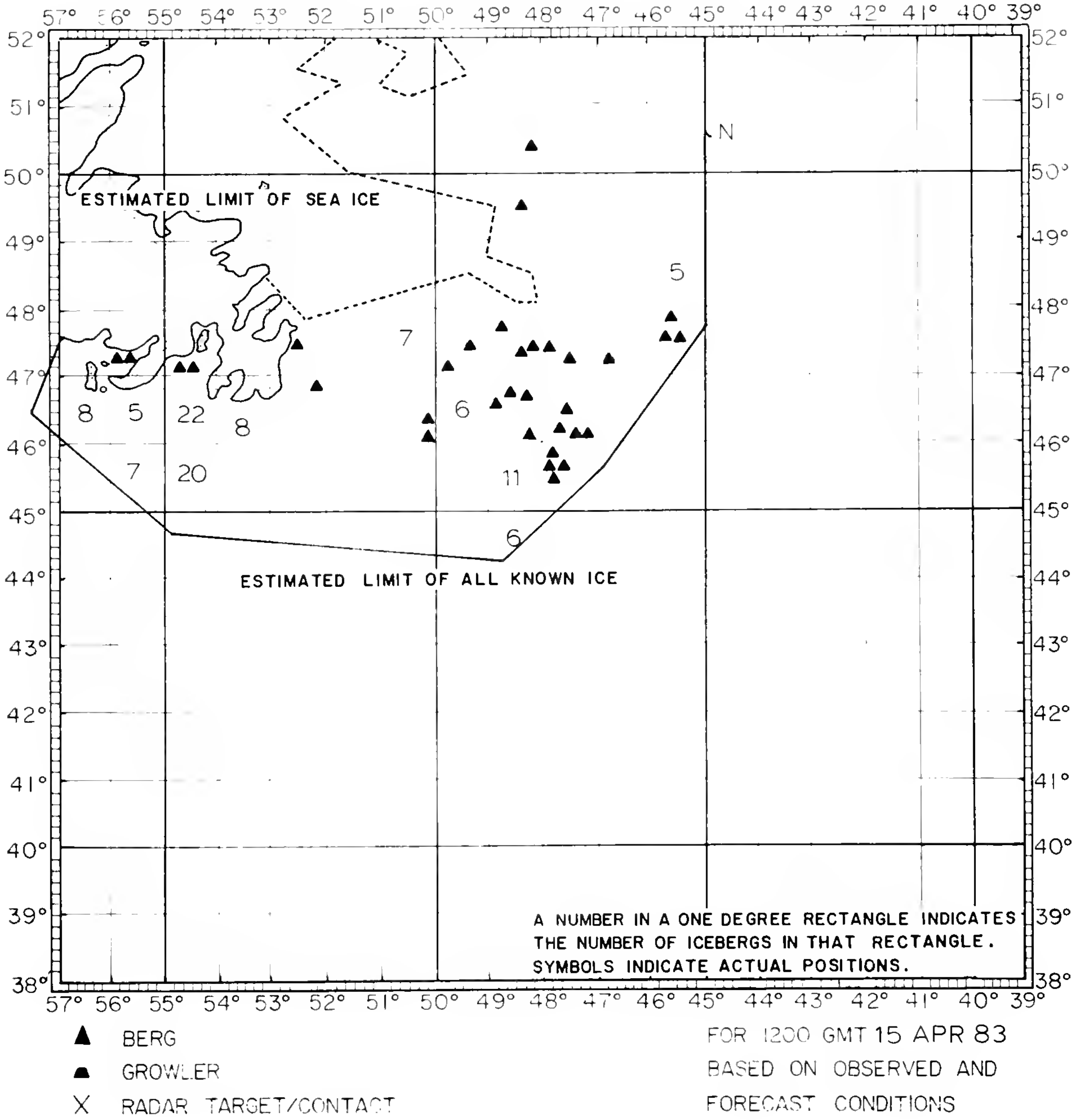
52° 51° 50° 49° 48° 47° 46° 45° 44° 43° 42° 41° 40° 39° 38°
ESTIMATED LIMIT OF SEA ICE
ESTIMATED LIMIT OF ALL KNOWN ICE
33
6
10
A NUMBER IN A ONE DEGREE RECTANGLE INDICATES THE NUMBER OF ICEBERGS IN THAT RECTANGLE. SYMBOLS INDICATE ACTUAL POSITIONS.
BERG
GROWLER
X RADAR TARGET/CONTACT
FOR 1200 GMT 15 MAR 83
BASED ON OBSERVED AND
FORECAST CONDITIONS

Figure 16



57° 56° 55° 54° 53° 52° 51° 50° 49° 48° 47° 46° 45° 44° 43° 42° 41° 40° 39°
52° 51° 50° 49° 48° 47° 46° 45° 44° 43° 42° 41° 40° 39° 38°
ESTIMATED LIMIT OF SEA ICE
N
16
8
ESTIMATED LIMIT OF ALL KNOWN ICE
A NUMBER IN A ONE DEGREE RECTANGLE INDICATES THE NUMBER OF ICEBERGS IN THAT RECTANGLE. SYMBOLS INDICATE ACTUAL POSITIONS.
BERG
GROWLER
X RADAR TARGET/CONTACT
FOR 1200 GMT 30 MAR 83
BASED ON OBSERVED AND FORECAST CONDITIONS

Figure 17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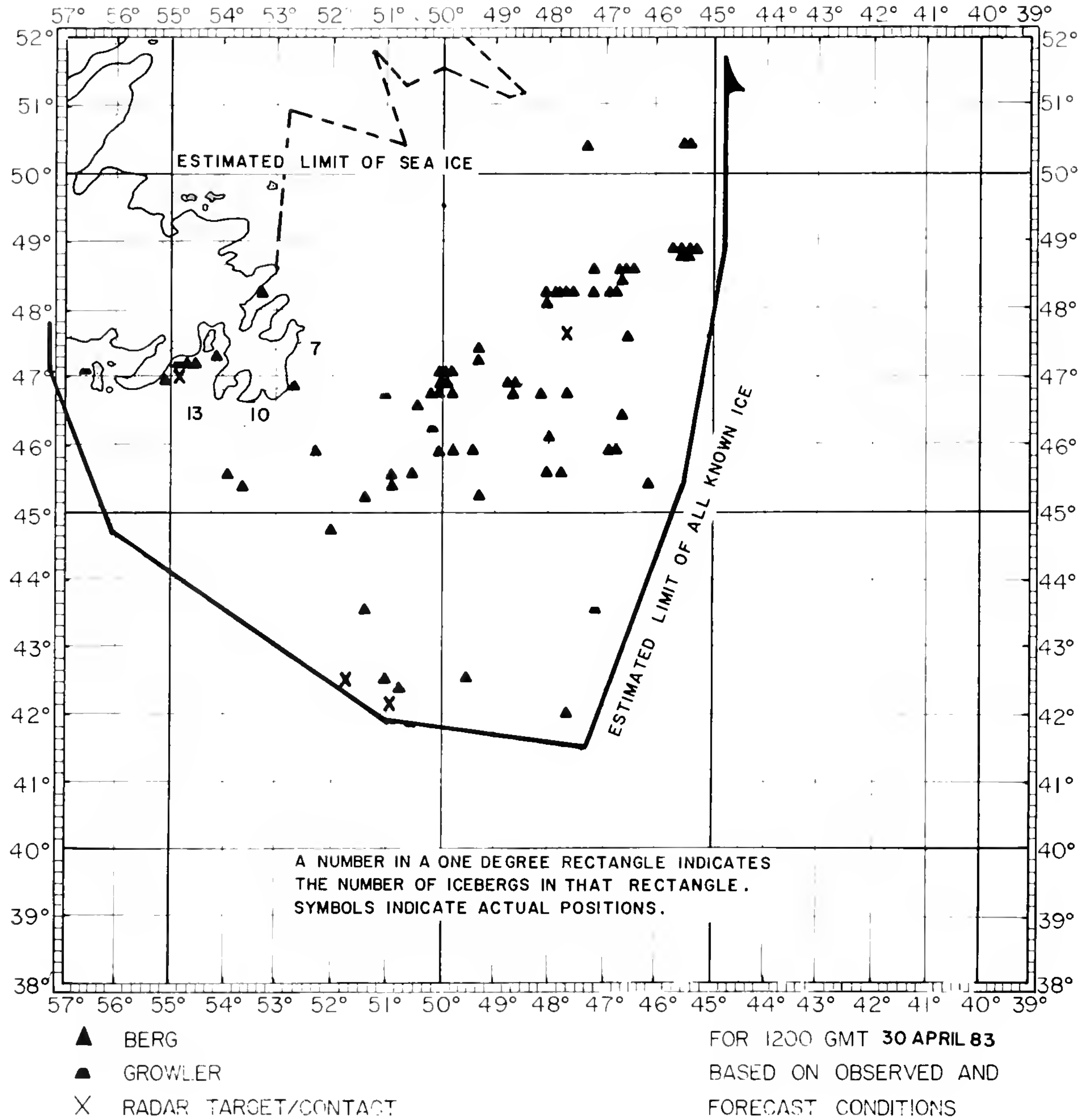
52° 51° 50° 49° 48° 47° 46° 45° 44° 43° 42° 41° 40° 39° 38°
N
ESTIMATED LIMIT OF SEA ICE
5
7
8 5 22 8
6
7 20
11
6
ESTIMATED LIMIT OF ALL KNOWN ICE
A NUMBER IN A ONE DEGREE RECTANGLE INDICATES THE NUMBER OF ICEBERGS IN THAT RECTANGLE. SYMBOLS INDICATE ACTUAL POSITIONS.
BERG
GROWLER
X RADAR TARGET/CONTACT
FOR 1200 GMT 15 APR 83
BASED ON OBSERVED AND FORECAST CONDITIONS

Figure 18



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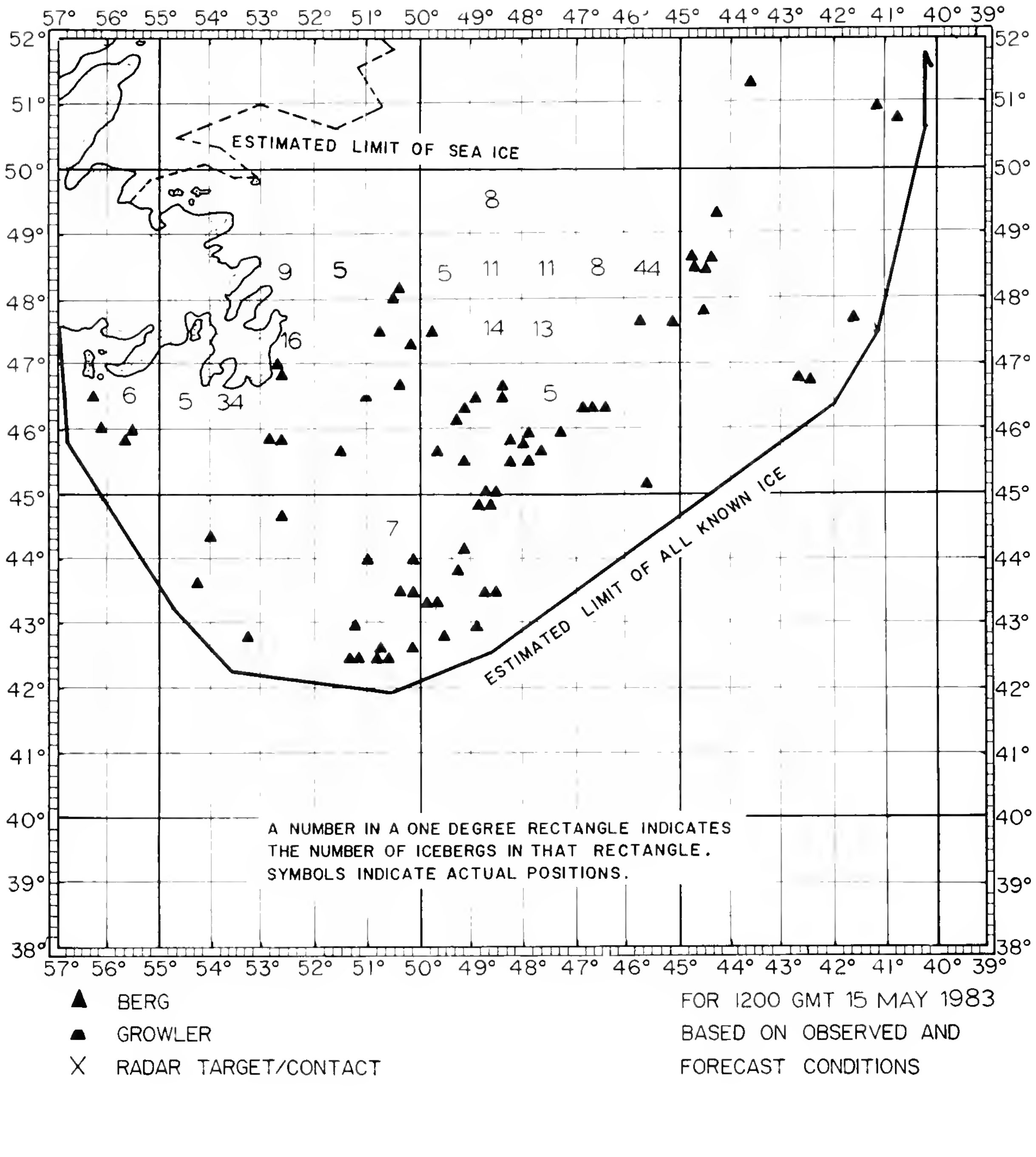
52° 51° 50° 49° 48° 47° 46° 45° 44° 43° 42° 41° 40° 39° 38°
ESTIMATED LIMIT OF SEA ICE
ESTIMATED LIMIT OF ALL KNOWN ICE
7
13
10
A NUMBER IN A ONE DEGREE RECTANGLE INDICATES
THE NUMBER OF ICEBERGS IN THAT RECTANGLE.
SYMBOLS INDICATE ACTUAL POSITIONS.
BERG
GROWLER
RADAR TARGET/CONTACT
FOR 1200 GMT 30 APRIL 83
BASED ON OBSERVED AND
FORECAST CONDITIONS

Figure 19



ESTIMATED LIMIT OF SEA ICE
ESTIMATED LIMIT OF ALL KNOWN ICE
A NUMBER IN A ONE DEGREE RECTANGLE INDICATES THE NUMBER OF ICEBERGS IN THAT RECTANGLE. SYMBOLS INDICATE ACTUAL POSITIONS.
BERG
GROWLER
X RADAR TARGET/CONTACT
FOR 1200 GMT 15 MAY 1983
BASED ON OBSERVED AND FORECAST CONDITIONS

Figure 20

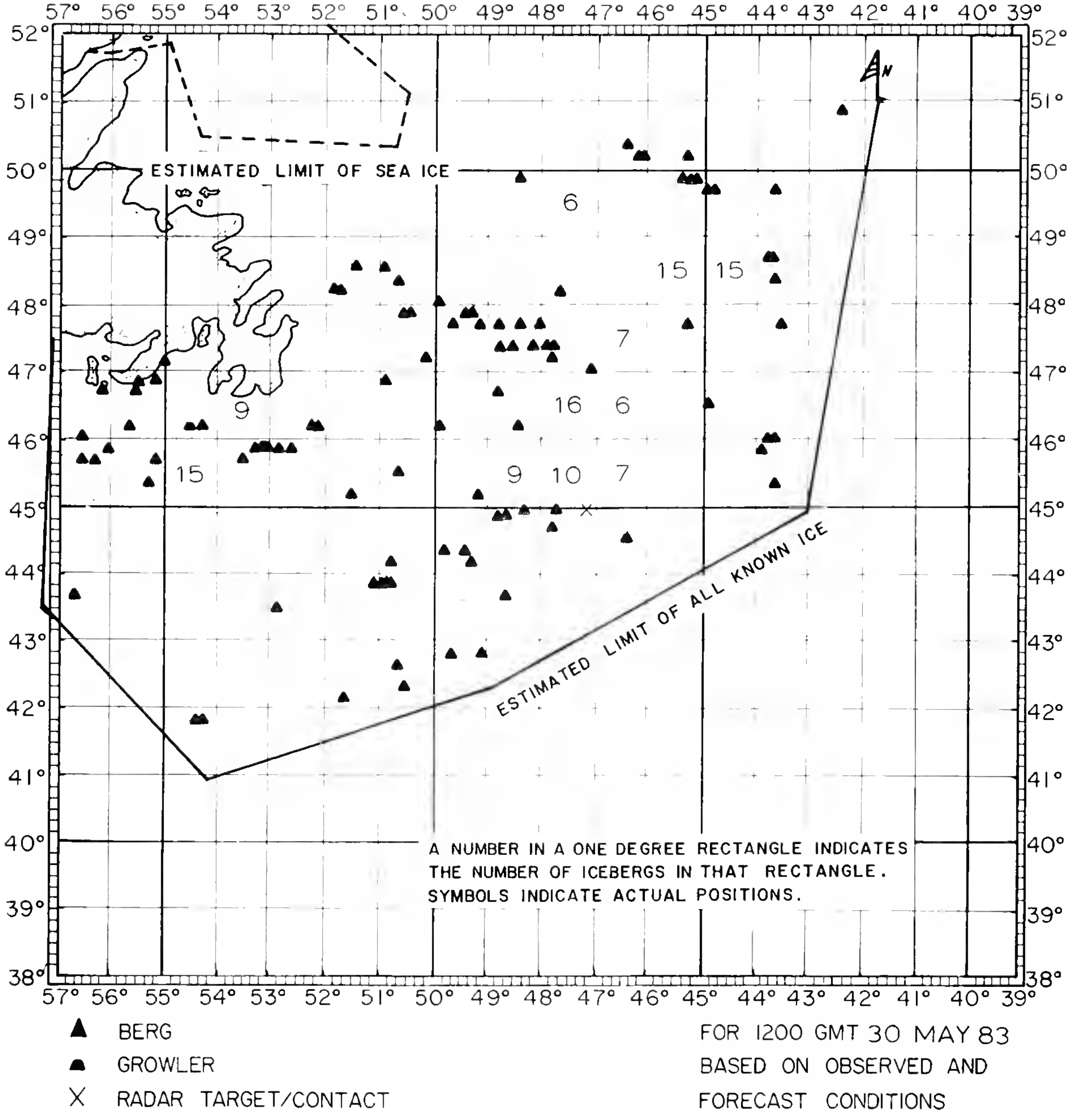

57° 56° 55° 54° 53° 52° 51° 50° 49° 48° 47° 46° 45° 44° 43° 42° 41° 40° 39°
52° 51° 50° 49° 48° 47° 46° 45° 44° 43° 42° 41° 40° 39° 38°
ESTIMATED LIMIT OF SEA ICE
ESTIMATED LIMIT OF ALL KNOWN ICE
6
15 15
7
9
16 6
15
9 10 7
A NUMBER IN A ONE DEGREE RECTANGLE INDICATES THE NUMBER OF ICEBERGS IN THAT RECTANGLE. SYMBOLS INDICATE ACTUAL POSITIONS.
BERG
GROWLER
X RADAR TARGET/CONTACT
FOR 1200 GMT 30 MAY 83
BASED ON OBSERVED AND FORECAST CONDITIONS

Figure 21

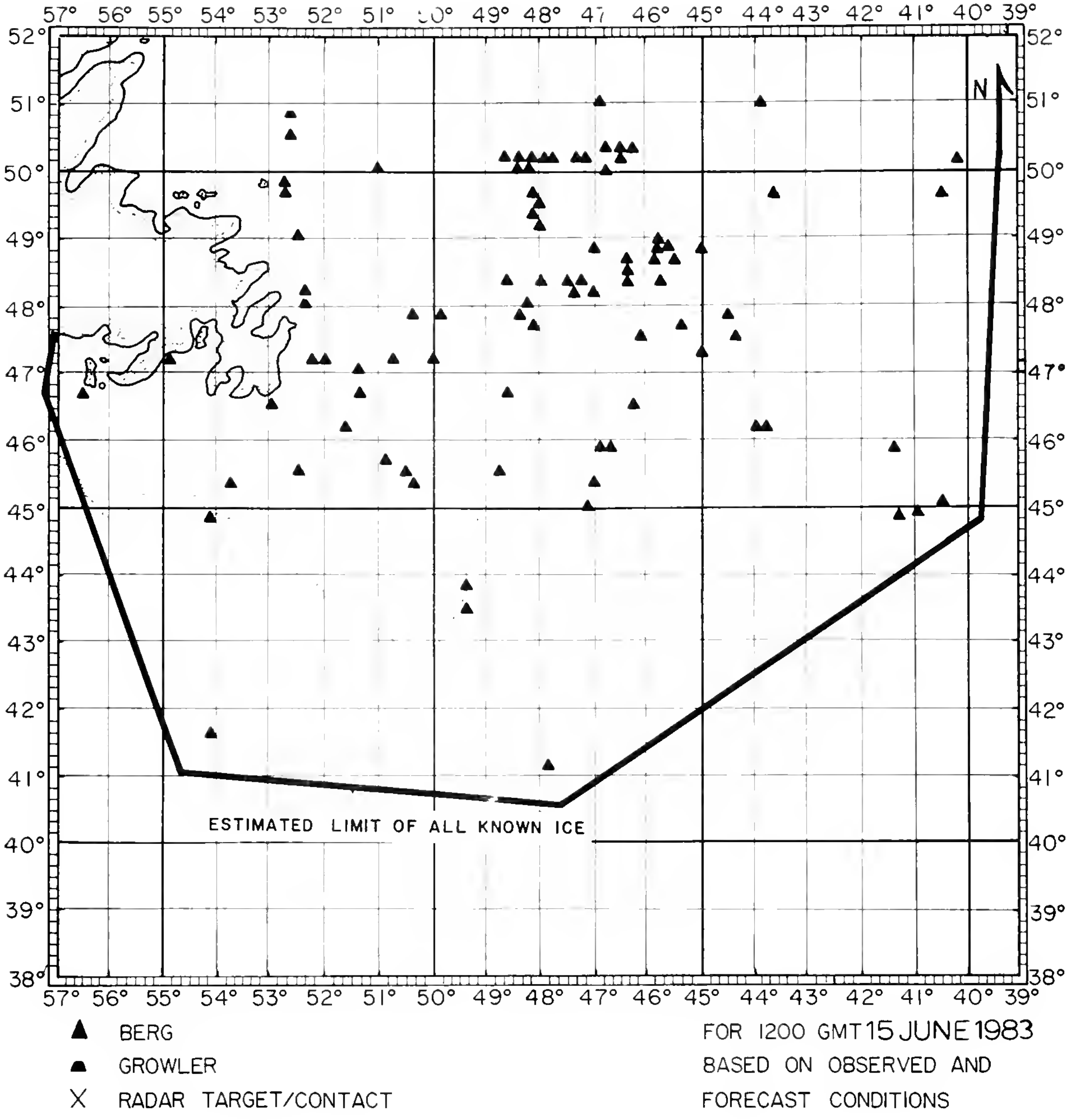
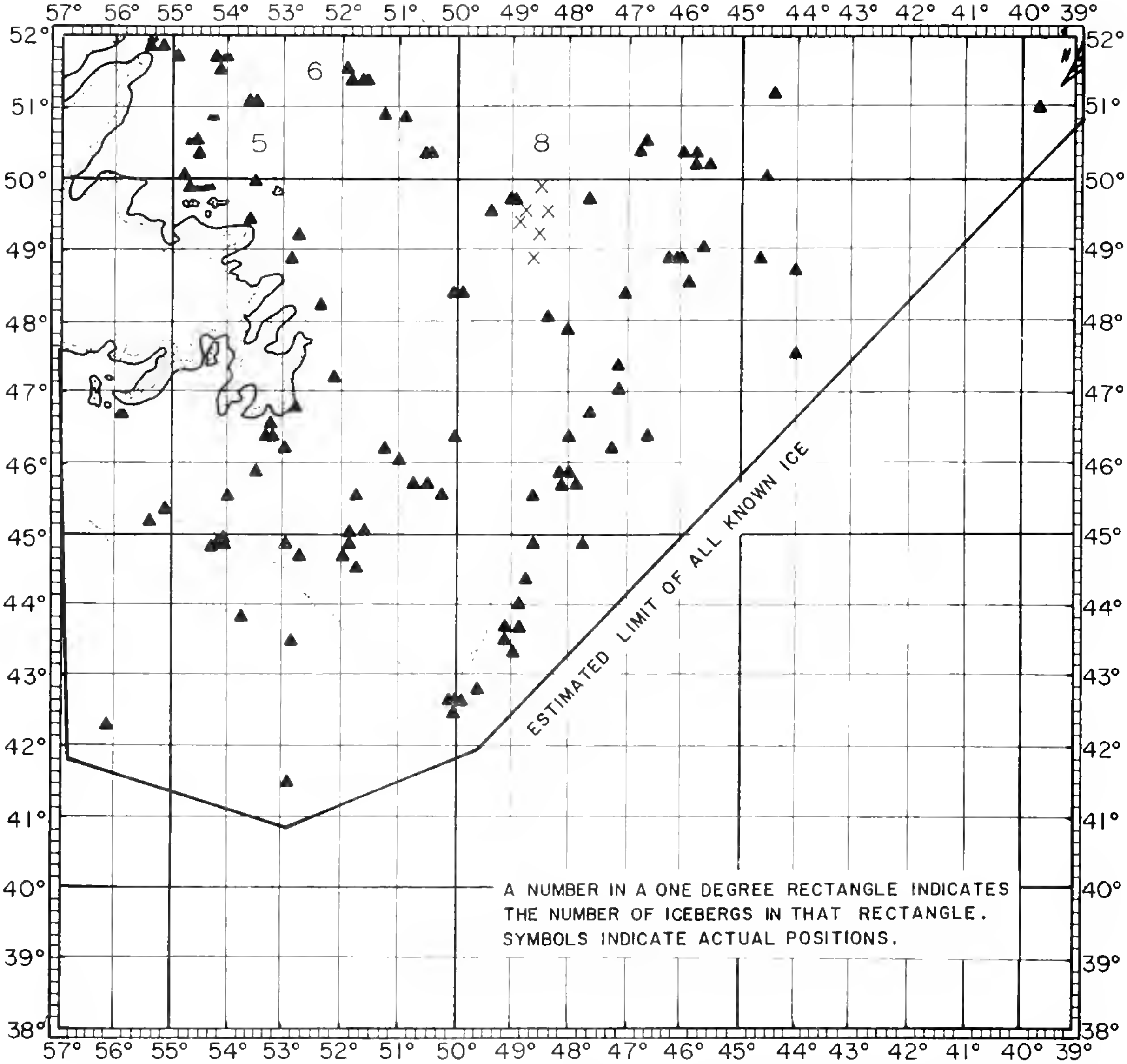

ESTIMATED LIMIT OF ALL KNOWN ICE
N
BERG
GROWLER
X RADAR TARGET/CONTACT
FOR 1200 GMT 15 JUNE 1983
BASED ON OBSERVED AND
FORECAST CONDITIONS

Figure 22



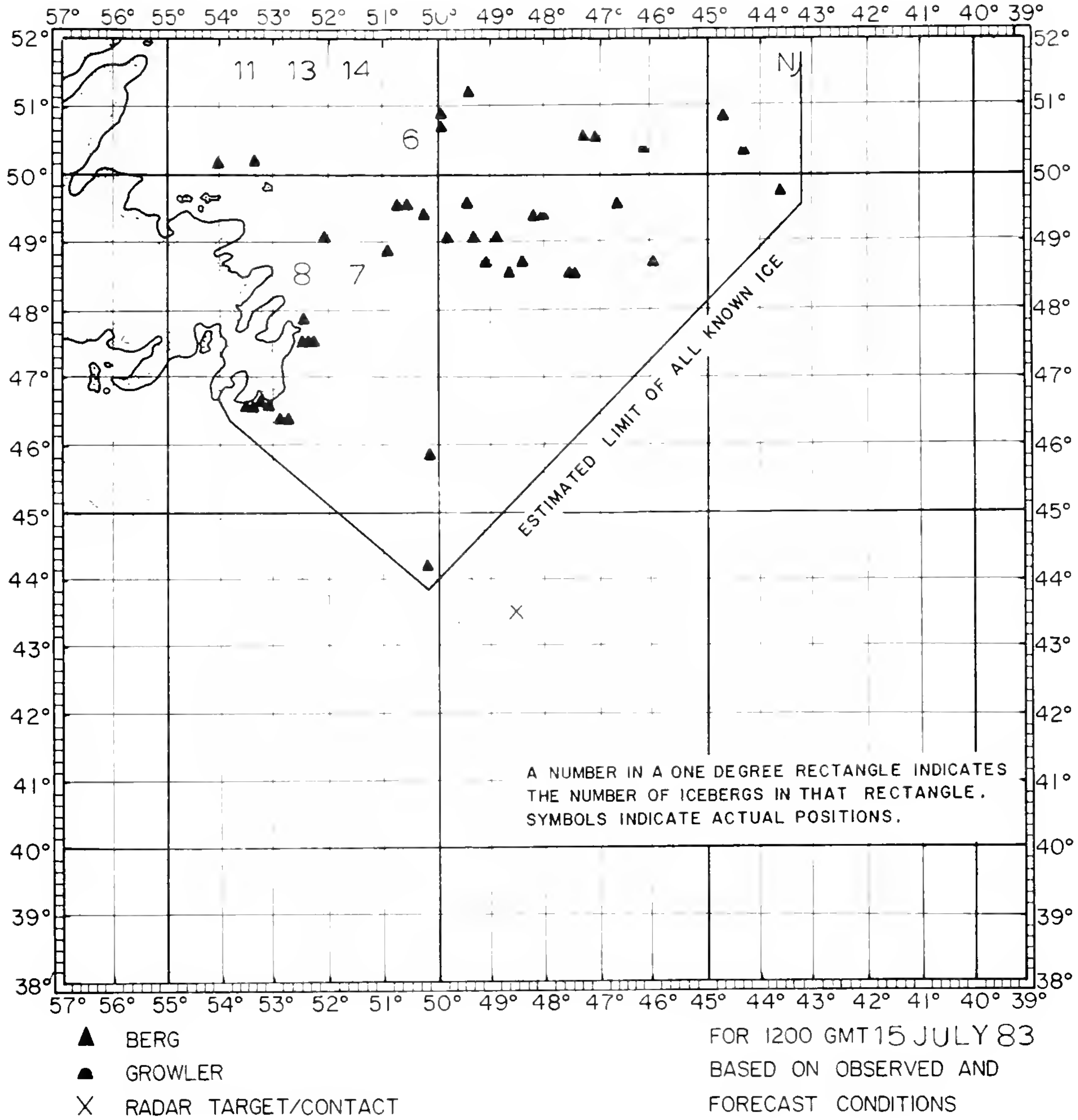
▲ BERG

GROWLER

X RADAR TARGET/CONTACT

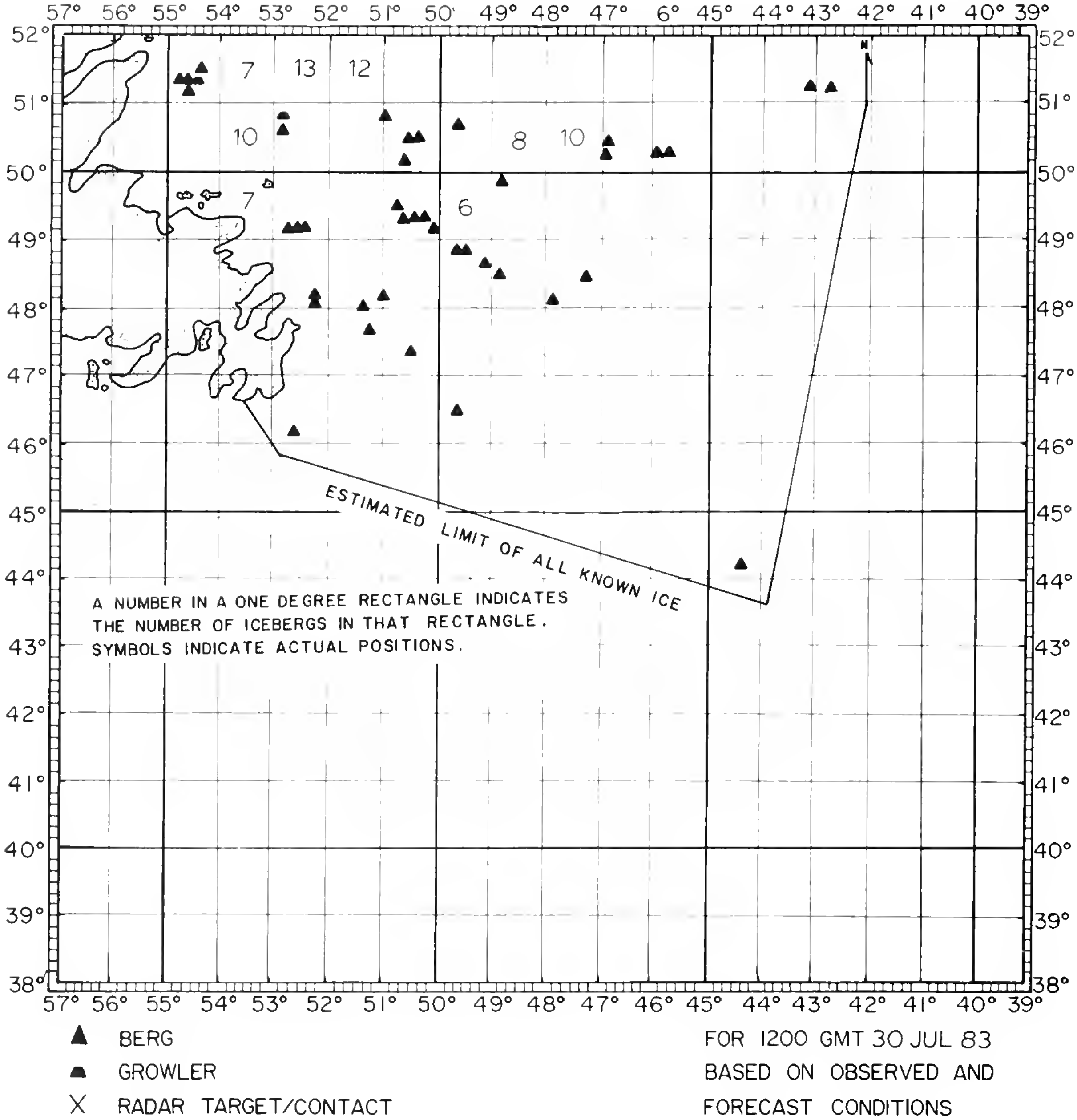
FOR 1200 GMT 30 JUNE 83
BASED ON OBSERVED AND
FORECAST CONDITIONS

Figure 23



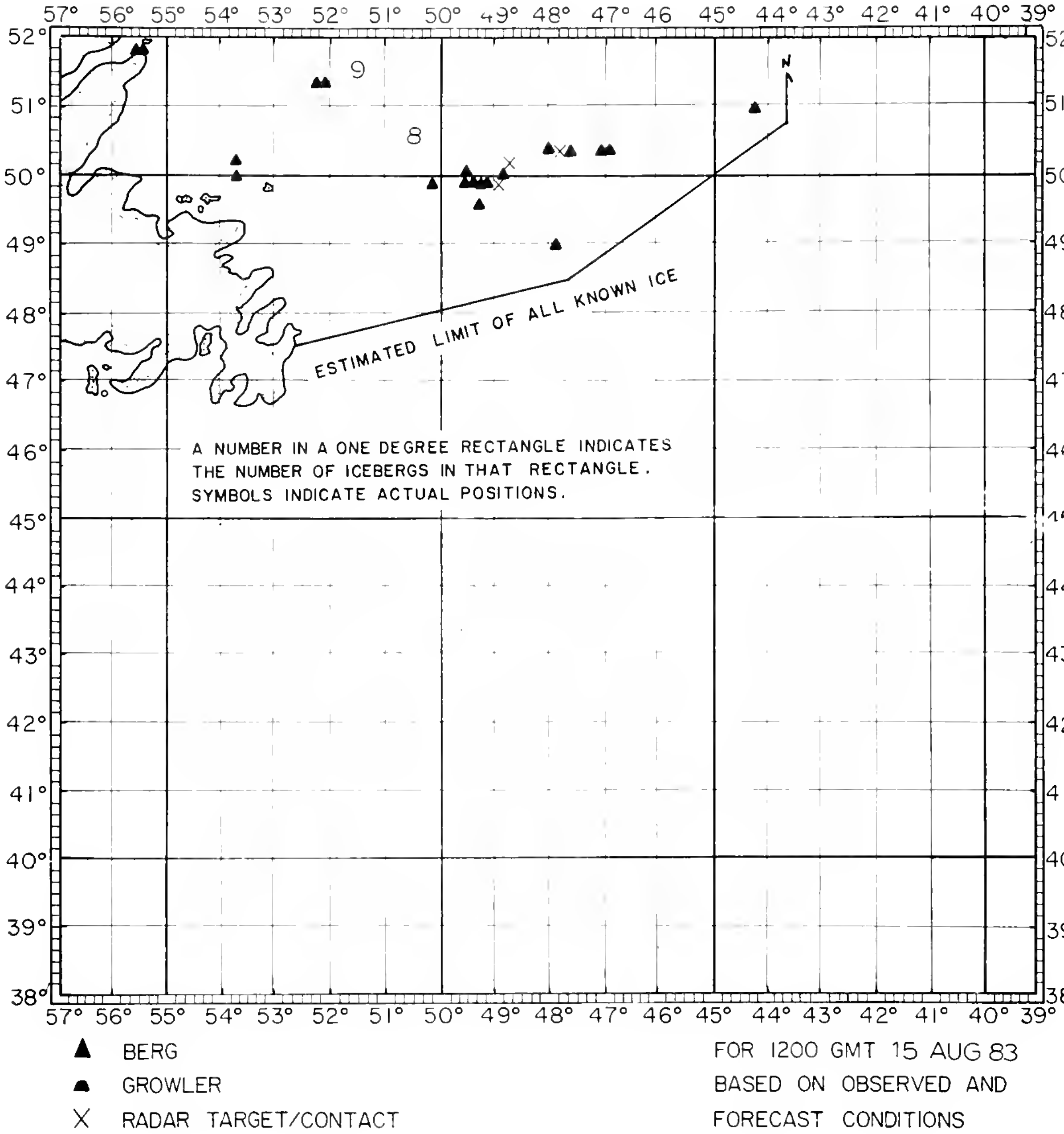
11
13
14
6
8
7
N
ESTIMATED LIMIT OF ALL KNOWN ICE
A NUMBER IN A ONE DEGREE RECTANGLE INDICATES THE NUMBER OF ICEBERGS IN THAT RECTANGLE. SYMBOLS INDICATE ACTUAL POSITIONS.
BERG
GROWLER
RADAR TARGET/CONTACT
FOR 1200 GMT 15 JULY 83
BASED ON OBSERVED AND FORECAST CONDITIONS

Figure 24



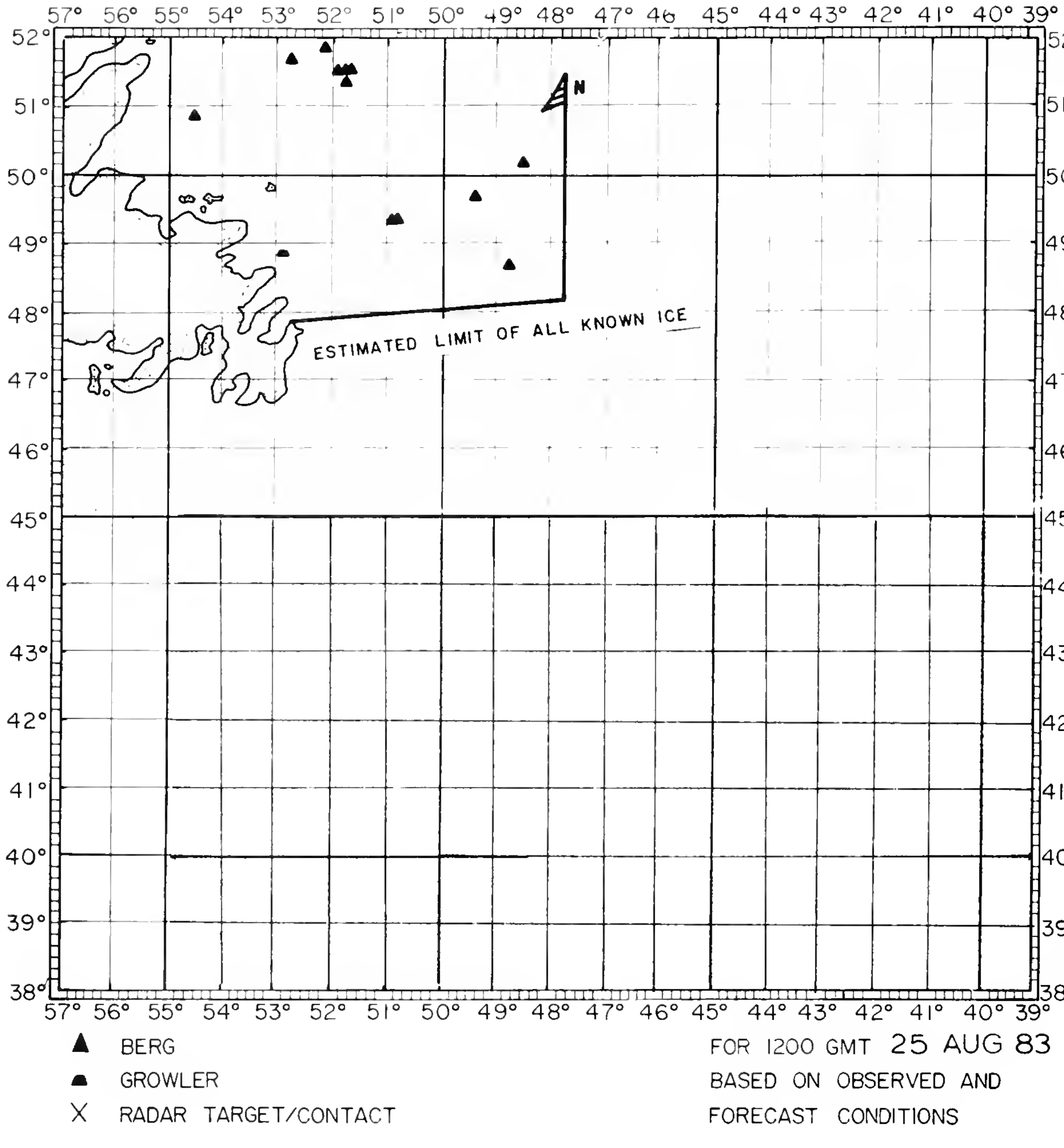
57° 56° 55° 54° 53° 52° 51° 50° 49° 48° 47° 46° 45° 44° 43° 42° 41° 40° 39°
52° 51° 50° 49° 48° 47° 46° 45° 44° 43° 42° 41° 40° 39° 38°
7
13
12
10
8
10
7
6
ESTIMATED LIMIT OF ALL KNOWN ICE
A NUMBER IN A ONE DEGREE RECTANGLE INDICATES THE NUMBER OF ICEBERGS IN THAT RECTANGLE. SYMBOLS INDICATE ACTUAL POSITIONS.
BERG
GROWLER
X RADAR TARGET/CONTACT
FOR 1200 GMT 30 JUL 83
BASED ON OBSERVED AND FORECAST CONDITIONS

Figure 25



ESTIMATED LIMIT OF ALL KNOWN ICE
A NUMBER IN A ONE DEGREE RECTANGLE INDICATES THE NUMBER OF ICEBERGS IN THAT RECTANGLE. SYMBOLS INDICATE ACTUAL POSITIONS.
9
8
N
57° 56° 55° 54° 53° 52° 51° 50° 49° 48° 47° 46 45° 44° 43° 42° 41° 40° 39°
52° 51° 50° 49° 48° 47° 46° 45° 44° 43° 42° 41° 40° 39° 38°
BERG
GROWLER
RADAR TARGET/CONTACT
FOR 1200 GMT 15 AUG 83
BASED ON OBSERVED AND FORECAST CONDITIONS

Figure 26


57° 56° 55° 54° 53° 52° 51° 50° 49° 48° 47° 46 45° 44° 43° 42° 41° 40° 39°
52° 51° 50° 49° 48° 47° 46° 45° 44° 43° 42° 41° 40° 39° 38°
N
ESTIMATED LIMIT OF ALL KNOWN ICE
BERG
GROWLER
X RADAR TARGET/CONTACT
FOR 1200 GMT 25 AUG 83
BASED ON OBSERVED AND
FORECAST CONDITIONS

Discussion of Iceberg and Environmental Conditions

There are a number of factors which affect the number of icebergs that will reach the Grand Banks during a particular ice season. These include the number of bergs that calve from glaciers each year, the ocean currents carrying these bergs south along the Labrador and Newfoundland coasts, the winds which help to move these bergs, the sea ice which tends to retard the movement of bergs and protect those trapped within its limits, and the environmental conditions which affect the melt rates of the bergs (air and sea surface temperature, storm activity, etc.). Each of these factors has some effect on the extent of the iceberg season off Newfoundland.

The 1983 Ice Patrol season was the third heaviest season on record with an estimated 1352 icebergs drifting south of 48°N. This was considerably more than the 1900-1983 annual average of 381, though less than the maximum number of 1587, recorded during the 1972 season.

Each year thousands of icebergs calve from the glaciers on Greenland's west coast, providing a more than ample supply of bergs in Baffin Bay. The fluctuation in this number of bergs is generally considered to be a minor factor in the number of bergs reaching the Grand Banks because the winds must be favorable to drift the icebergs south and the sea ice must be present to protect them during their long journey. Therefore, International Ice Patrol did not fly any pre-season patrols north of 53°N in 1983.

The air temperatures (Table 4) have been compared with the heavy sea ice conditions experienced during the 1983 Ice Patrol season. Other environmental factors (winds and atmospheric pressures) are discussed in this section in an attempt to explain the large number of icebergs this season. The Oceanographic Conditions section (Appendix B) examines some of the features of the Labrador and North Atlantic Currents that the Ice Patrol observed during the 1983 season.

Figures 27 through 34 depict the sea surface pressure patterns for January through August 1983 and the normal patterns for those months. When interpreting these figures, the isobars, drawn as heavy solid lines, are used to determine an average wind direction. Winds tend to blow parallel with the isobars, counterclockwise around low pressure cells in northern latitudes.

The predominant characteristic of the monthly average sea surface pressures was the meandering Icelandic Low. The January position of the low was located northeast of its normal position and was more intense than normal (Figure 27). This produced a southwesterly wind flow over east Newfoundland waters which helped to slow the progress of sea ice in that area. Farther north, the predominant winds were from the north, producing rapid growth of the ice in Davis Strait and off the northern Labrador Coast (see Figure 4). This low shifted south in February (Figure 28), bringing northerly winds which allowed the pack ice to surge southward as illustrated in Figure 5. The Icelandic Low moved back to the northeast again in March (Figure 29), where it was much deeper than normal, as experienced during the 1972 Ice Patrol season, the heaviest on record. This brought westerly winds along the shores of Newfoundland and northerly winds off Labrador, moving the ice south and offshore (compare Figures 6 and 7). It also released some of the icebergs trapped in the sea ice, helping to account for the increase in berg sightings during the early part of April (see Figure 17). The low moved east of Iceland during April (Figure 30) and remained there through May (Figure 31). This produced predominantly southeasterly winds over the Grand Banks during April and westerly winds in May which aided in sea ice melt and disintegration (see Figures 7 and 8) and caused the icebergs to move further eastward (see Figures 18 and 19). The Icelandic Low moved westward in June (Figure 32), centering itself near southern Greenland. It remained in this area through July (Figure 33) and August (Figure 34). The southerly winds produced by this weather system brought warm water (as described in Appendix B) up through the Grand Banks, pushing the sea ice and iceberg limits slowly northward as illustrated in Figures 22 through 25.

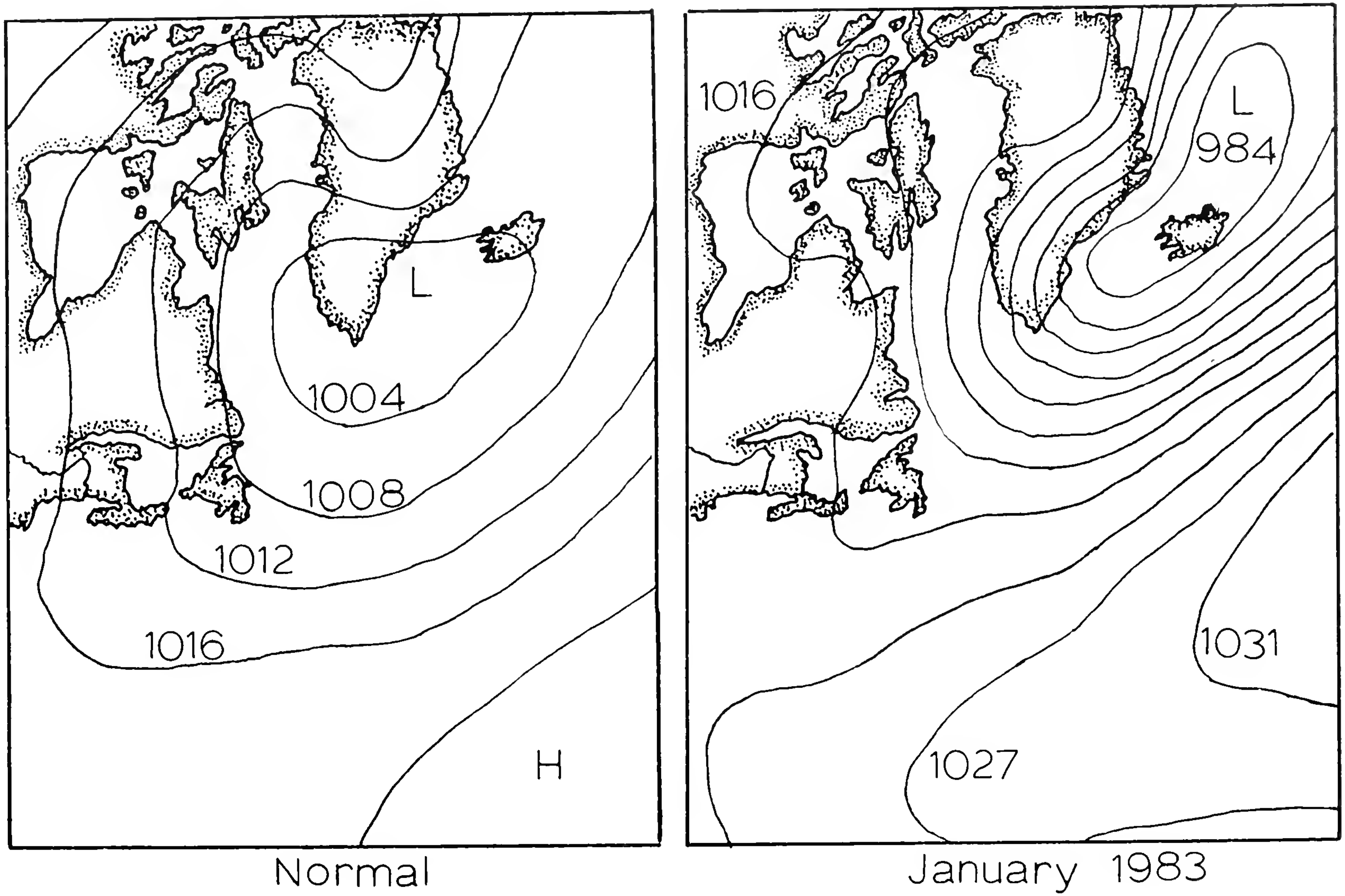


Figure 27

January 1983 - Normal (1948-1970) Monthly Average Surface Pressure (mb).

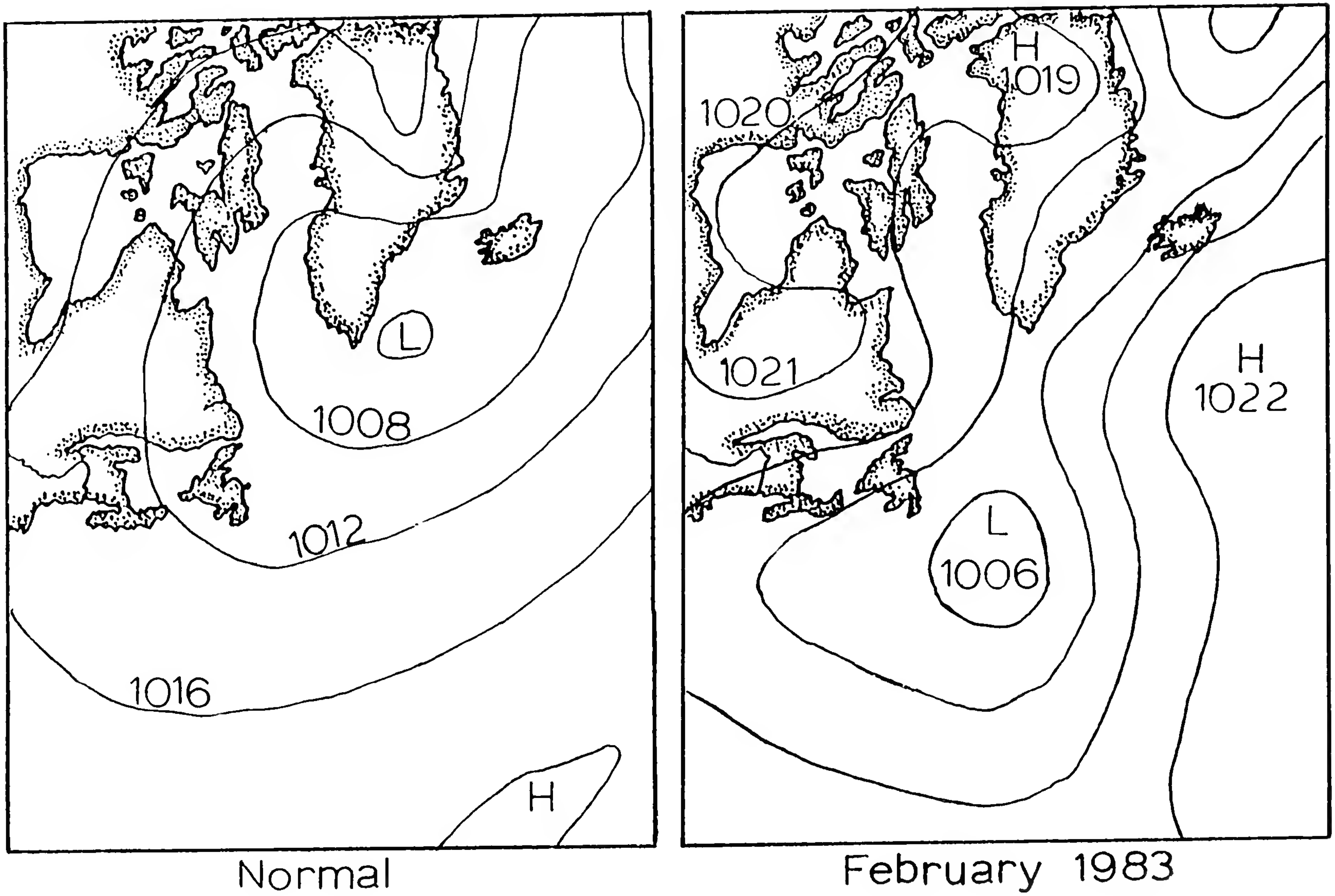


Figure 28

February 1983 - Normal (1948-1970) Monthly Average Surface Pressure (mb).

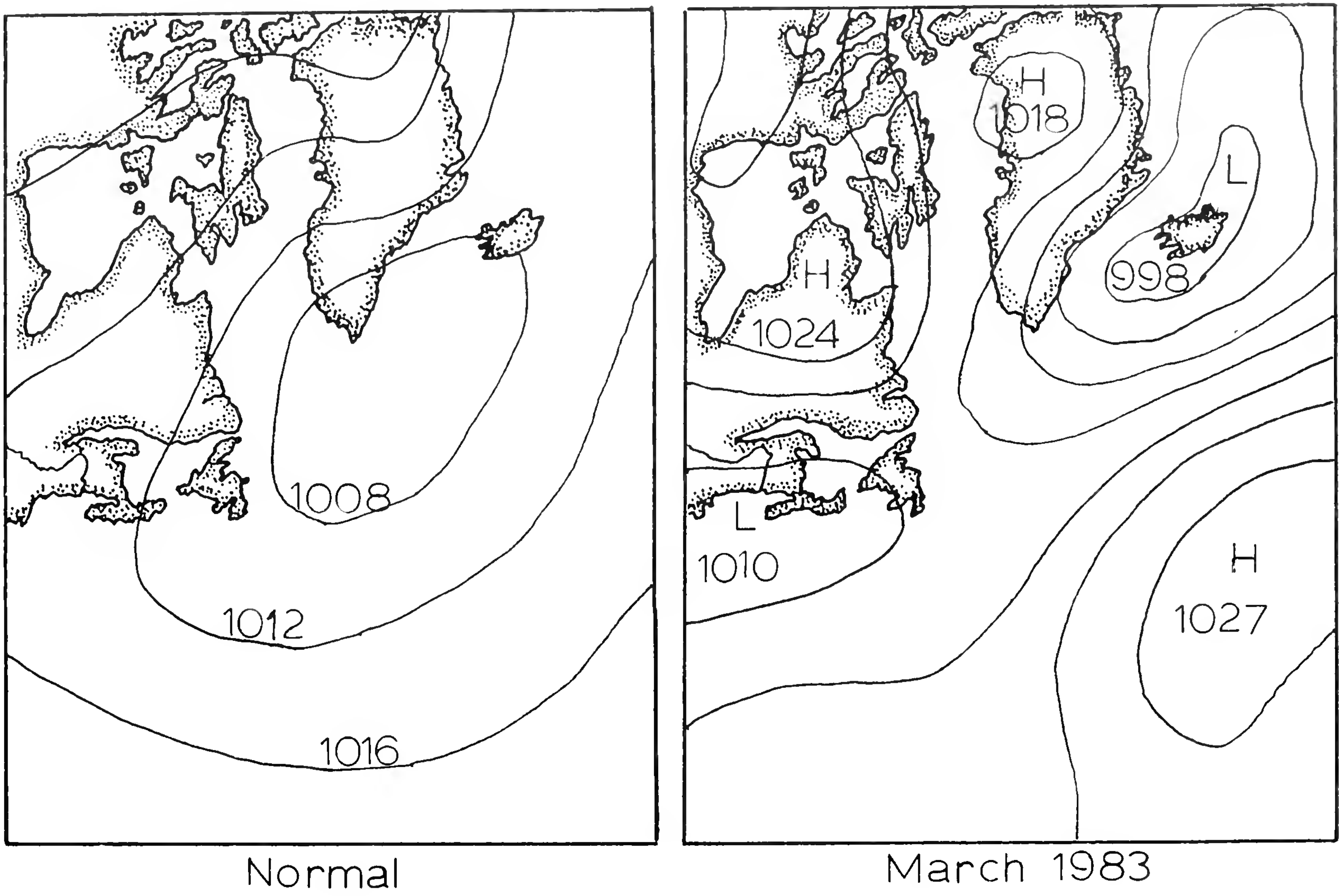


Figure 29

March 1983 - Normal (1948-1970) Monthly Average Surface Pressure (mb).

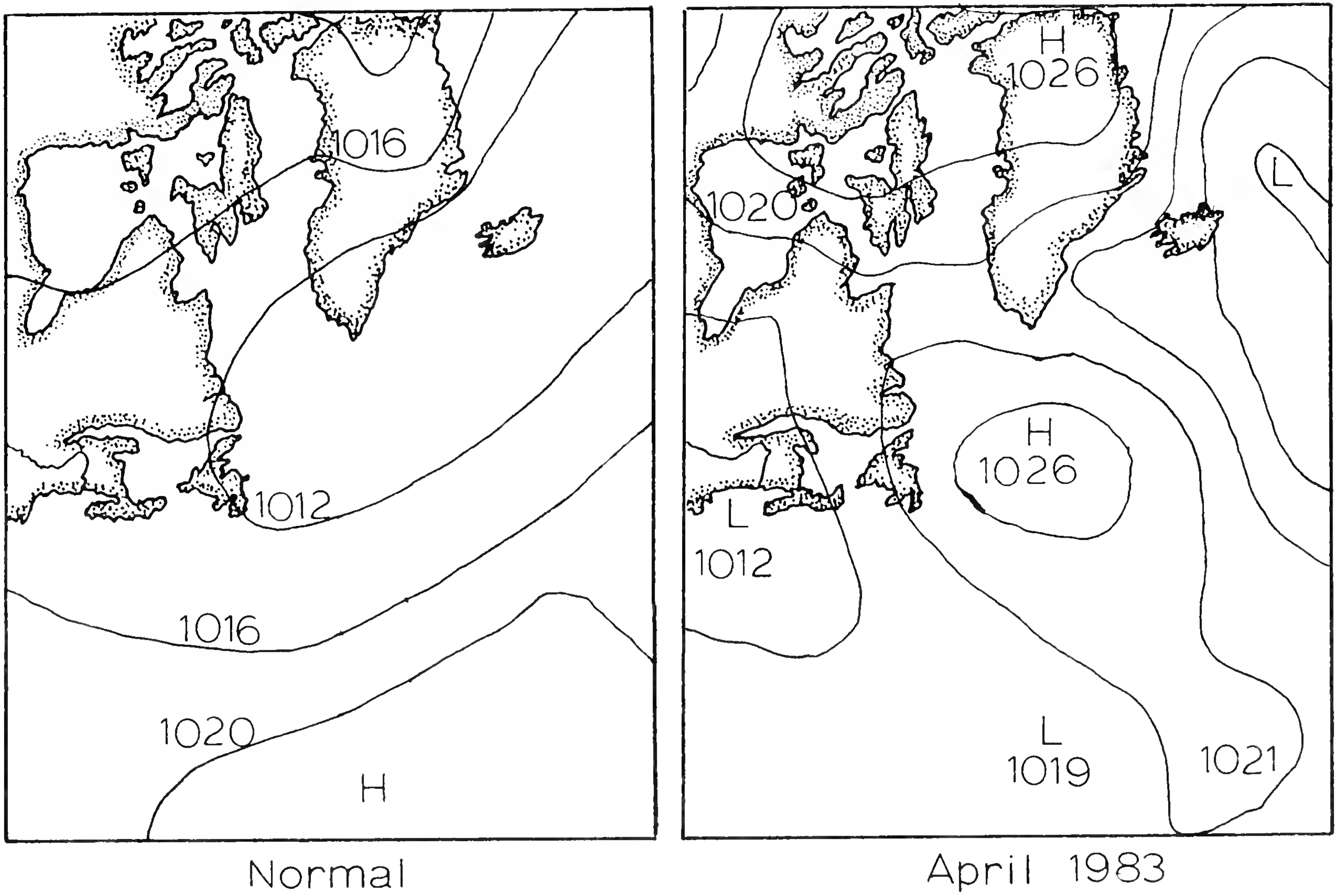


Figure 30

April 1983 - Normal (1948-1970) Monthly Average Surface Pressure (mb).

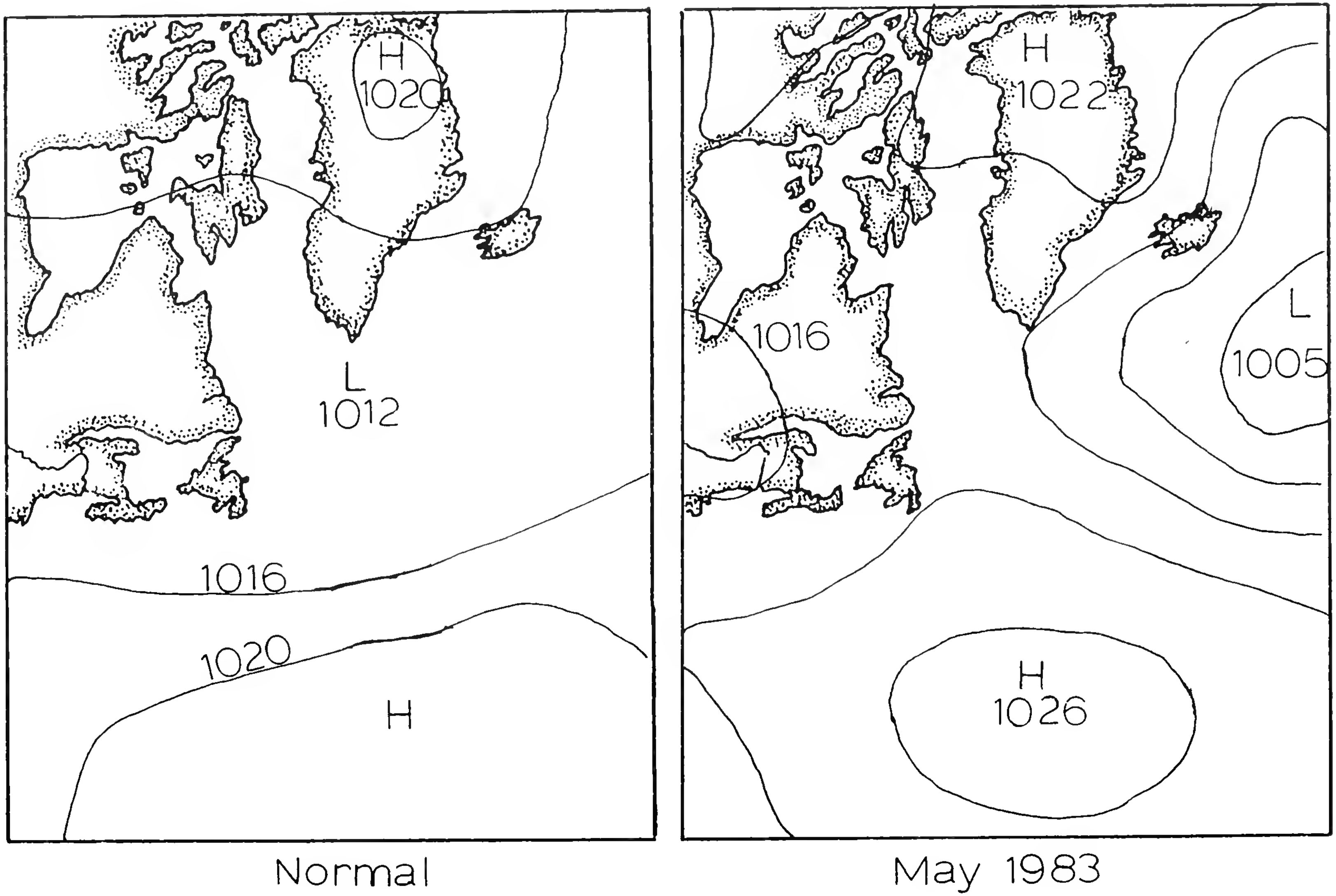


Figure 31

May 1983 - Normal (1948-1970) Monthly Average Surface Pressure (mb).

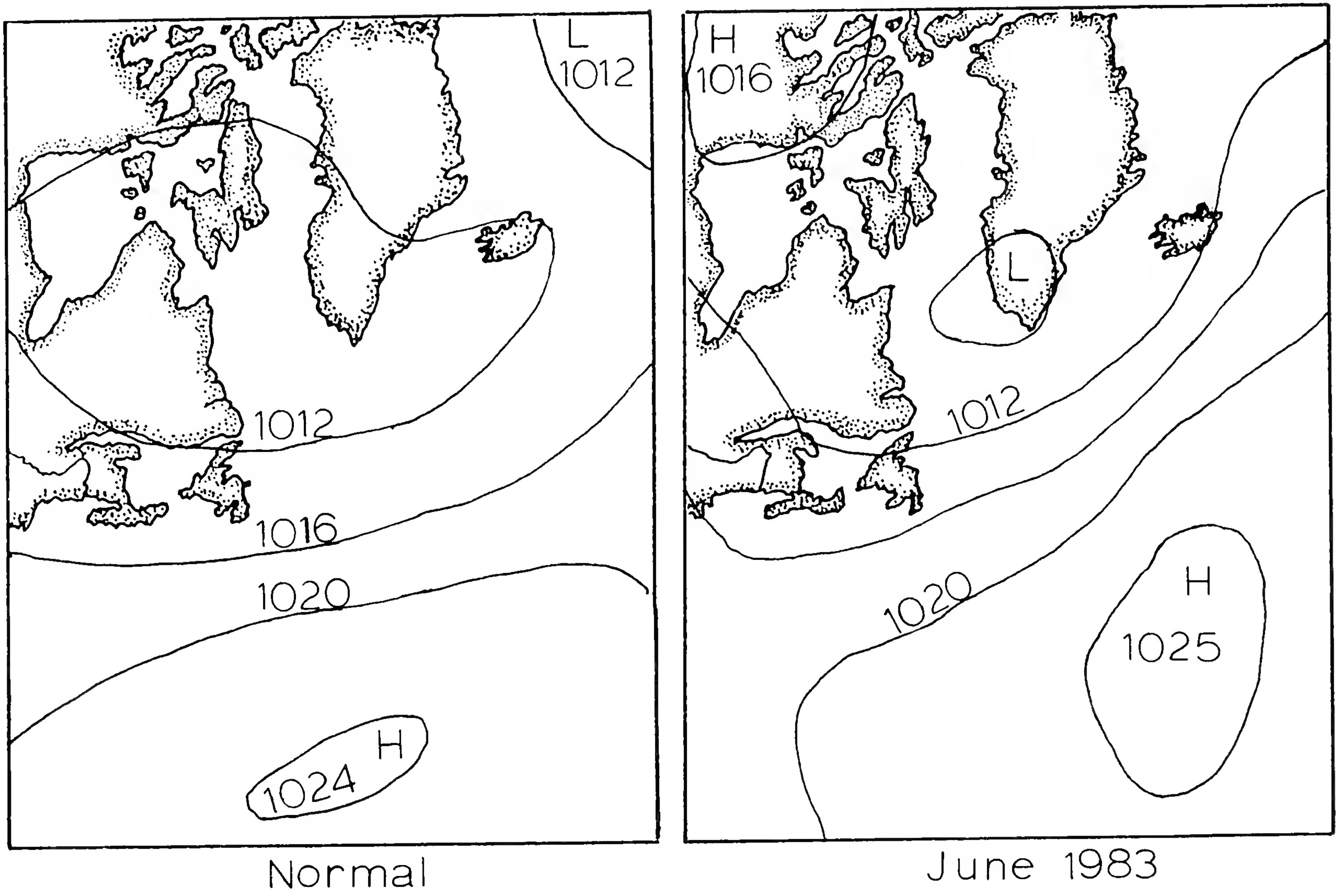


Figure 32

June 1983 - Normal (1948-1970) Monthly Average Surface Pressure (mb).

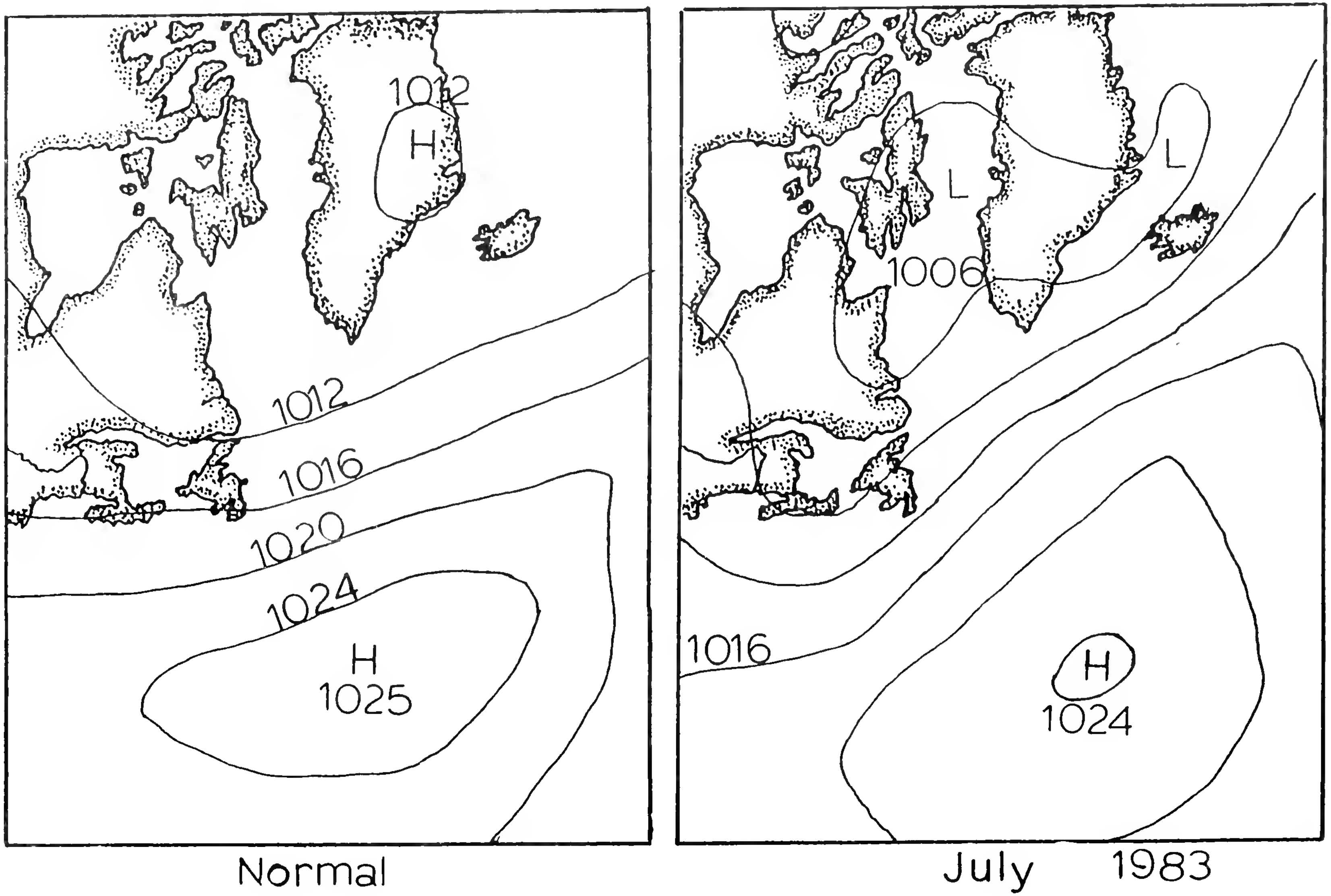


Figure 33

July 1983 - Normal (1948-1970) Monthly Average Surface Pressure (mb).

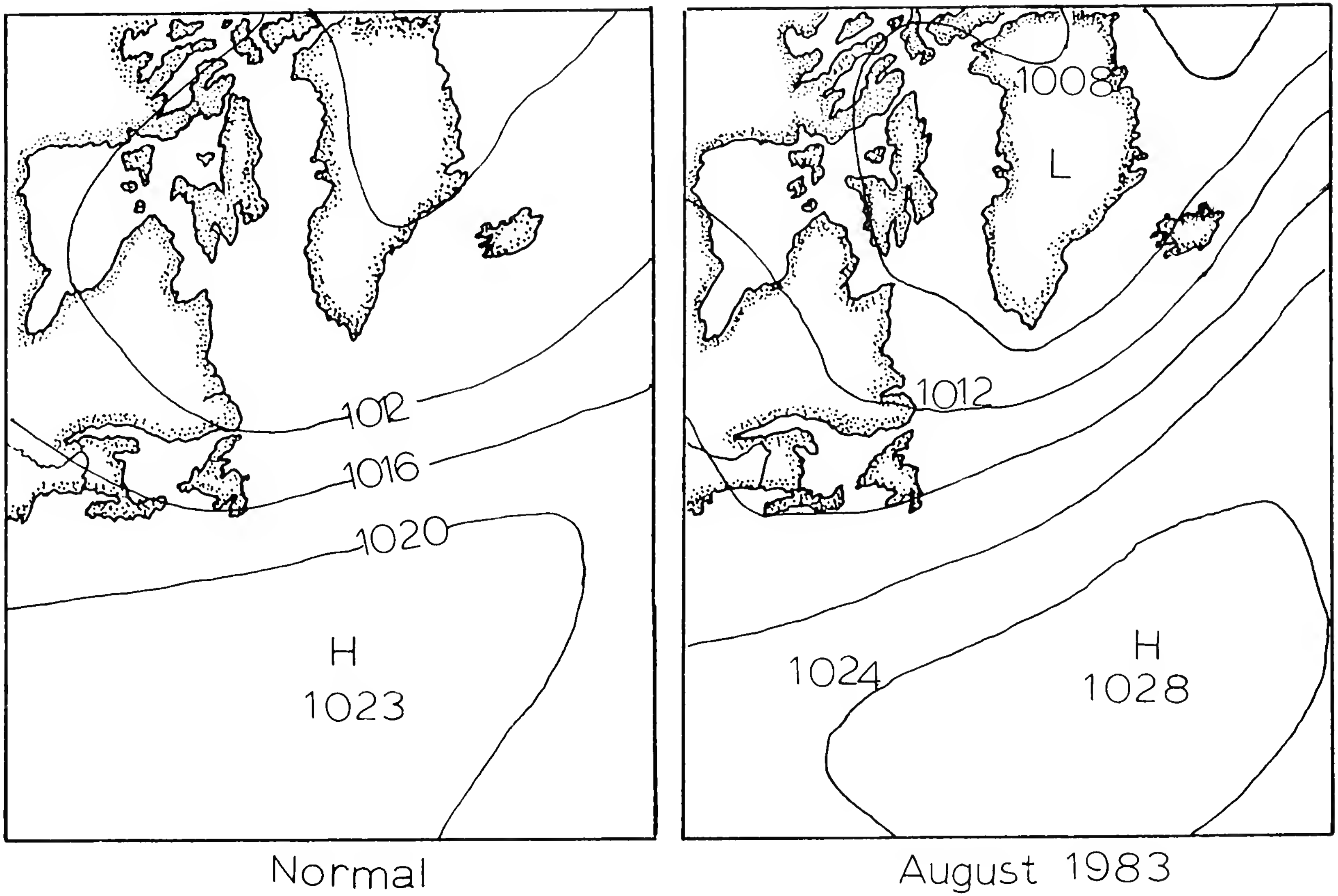


Figure 34

August 1983 - Normal (1948-1970) Monthly Average Surface Pressure (mb).

Acknowledgments

Commander, International Ice Patrol and his staff prepared this report and acknowledge the assistance and information provided by the Canadian Department of the Environment, the U. S. National Weather Service, the U. S. Naval Weather Service, and the U. S. Coast Guard Research and Development Center.

We extend our sincere appreciation to the staffs of the Canadian Coast Guard Radio Station St. John's, Newfoundland/VON, and the Gander Weather Office for their excellent support during the 1983 Ice Patrol season.

Appendix A

International Ice Patrol SST and Ice Reports for 1983

Ship's Name	Country of Registry	SST Reports	Ice Reports
CCGS Alfred Needler	Canada	0	1
Almare Quarta	Italy	0	8
Amandine	France	1	0
Ambassador	United Kingdom	0	4
Anastasios	Greece	0	1
Assiniboine	Canada	2	0
Atlantic Champagne	France	0	1
Atlantic Hawk	Greece	0	1
Atlantic Star	Greece	0	1
Bajka	Liberia	3	0
Balad	Liberia	3	0
Barken	Sweden	12	0
Batna	Japan	2	4
Berjaya	Singapore	1	0
Bourjniba	Morocco	2	0
Brunhorn	Singapore	0	1
Bruni	Norway	5	0
Brunla	Singapore	3	0
Buckeye	Liberia	0	1
Canadian Explorer	Canada	0	1
Cape Race	United Kingdom	0	1
Carrianna Peony	Panama	1	0
Carston	USSR	0	1
Cast Muskox	United Kingdom	0	1
Cast Otter	United Kingdom	0	1
Cinta	Liberia	18	3
City of Hartleypool	United Kingdom	2	1
Concort	United States	0	1
Contract Trader	Singapore	1	0
Corcalla	Panama	2	0
Coronia	Greece	4	0
Cygnus	Egypt	1	0
Dalmar	Singapore	0	1
Dart Atlantic	United Kingdom	0	3
Dart Continent	Belgium	0	1
Dart Europe	Belgium	0	2
Dawson	Canada	0	4
Don Juan	Sweden	1	0
Ekin	Turkey	1	0
Estelle J.	Panama	1	1
Ever Oasis	Panama	1	0
Evmar	Greece	1	1
E. W. Beatty	United Kingdom	0	1
Federal Hudson	Belgium	1	0
Federal Thames	Peru	0	1
Finnses	Liberia	3	0

Ship's Name	Country of Registry	SST Reports	Ice Reports
Fort Steele	United Kingdom	6	0
Franca	Italy	2	0
Francois Venture	Liberia	11	1
Frossok	Greece	0	2
Frotauguguai	Brazil	1	0
Fuji Reefer	Japan	1	1
Furia	Liberia	1	0
Grand Eagle	Panama	7	0
Galion	France	2	0
Garnet Ace	Panama	1	0
Gertrud Jacob	Germany	0	1
Grenfell	Canada	0	1
Holsten Crauiser	Panama	5	0
Harmonius	Panama	4	0
Heraklia	Panama	2	0
Holck Larsen	United Kingdom	1	0
Humberarm	Liberia	0	1
Hunter Bow	Liberia	0	1
Ivan Gorthon	Sweden	0	1
Jaques Cartier	France	3	3
James Transport	Canada	0	1
CCGS Jackman	Canada	0	1
Jalamauda	India	0	1
Jena	Germany	0	3
Johnson Chemspan	Sweden	2	0
Johanna Schulte	Cyprus	3	2
Kapitan Tsirul	USSR	0	1
Kelo	Finland	6	6
Kreuztrum	Germany	0	2
Lake Anne	Norway	11	0
Leros Island	Greece	0	1
Liebana	Spain	1	0
Lilienthal	Germany	0	1
Lutzschroeder	Germany	3	4
Malaye	Spain	1	0
Madzy	Sweden	3	0
Manchester Challenge	United Kingdom	2	3
Manila Mariner	Phillipines	6	0
Manolisl	Greece	0	1
Marramamba	Liberia	1	0
Marya Kamal	United Kingdom	0	1
Megapilot	Liberia	4	1
Meyashi Maru	Japan	0	1
Michele Damato	Italy	0	1
Monsun	Germany	2	1
Mount Eden	Liberia	12	0
Narica	Germany	9	0
Nadine	Liberia	0	2
Nedromo	Algeria	3	0
Nordheim	Singapore	5	3
Northern Shell	Canada	0	1
CGC Northwind	United States	41	0

Ship's Name	Country of Registry	SST Reports	Ice Reports
Nortranselma	Peru	0	2
Norwegerian Jarama	Norway	0	1
Ogden Danube	Liberia	3	0
Orkney	Panama	1	0
Pacific Challange	United Kingdom	0	4
Pacific Courage	United Kingdom	0	4
Pamero	Panama	1	1
Paysandu	Singapore	0	1
Peppino Damato	Italy	4	0
Polar Explorer	Canada	0	1
Premnitz	Germany	0	1
HMCS Protecteur	Canada	2	1
Puhos	Finland	0	1
Queen Elizabeth II	United Kingdom	1	4
Quest	Canada	0	1
Ravenscraig	United Kingdom	0	1
Rio Branco	Brazil	1	0
Rog	Liberia	0	1
Saarore	Liberia	1	1
St. Laurent	Liberia	0	1
Sir Humphrey Gilbert	Chile	0	3
Soodoc	Canada	2	3
Sounion	Greece	2	0
Stefan Batroy	Poland	0	8
Steregushchij	USSR	0	1
Stoltsydness	Liberia	1	0
Suiyo Maru	Japan	3	1
Sweelean	Japan	14	0
USNS Southern Cross	United States	11	0
Starman Australia	Greece	6	0
Sir Robert Bond	Canada	1	2
Sedco 716 (Oil Rig)	Canada	0	1
Takasaka	United Kingdom	1	1
Theano	Greece	4	0
Tesaba	Cyprus	1	0
Vishvaprafulla	India	0	2
Varjakka	Finland	30	1
Viking Hawk	Singapore	4	0
Vitabulik	Greece	1	1
Ziemia Olsztynska	Poland	5	0

Appendix B

Oceanographic Conditions on the Grand Banks During the 1983 International Ice Patrol Season

By Lieutenant Iain Anderson, USCG

Introduction

The 1983 Ice Patrol season marked the first time the International Ice Patrol (IIP) was able to operationally track an iceberg by satellite over an extended period of time (up to three months). This was accomplished in cooperation with the U. S. Coast Guard Research and Development Center by "tagging" three icebergs with TIROS Arctic Drifters (TAD). For the first time, real-time TIROS Oceanographic Drifter (TOD) information was used to permanently modify regions of the IIP historical current file.

During the 1983 season, seven TIROS Oceanographic Drifters (TOD) were deployed in the IIP operating area. The real-time current information obtained from the TOD drifts was used weekly to temporarily modify the IIP historical current field. The procedure used in this modification is described in detail in Summy (1982). With one exception, all of the TODs and TADs were air-dropped from a Coast Guard HC-130 aircraft during regular ice reconnaissance flights (Table B-1). The exception was TOD #2634 which was deployed from the USCGC NORTHWIND during cruise IIP-1-83. The main purposes of this cruise were to gather environmental data for comparison with that obtained from Fleet Numerical Oceanography Center (FNOC) and to obtain iceberg deterioration data. (For results of this cruise see Appendix C.)

TIROS Arctic Drifters

During March of 1983, three TADs were deployed on icebergs in the North Atlantic. Positions were determined by Doppler shift of the TAD transmitter's signal received at the satellite and relayed to the International Ice Patrol office via Service ARGOS. Before deployment, the outer cases of all the TADs had been sealed with a waterproofing gasket material, to prohibit spray and moisture from damaging the electronics. Unfortunately, the TAD's would float after falling off an iceberg. Without temperature information, it was difficult to determine exactly when a TAD fell off its iceberg. TAD #2611 was deployed on a large tabular iceberg trapped in the sea ice on 27 March 1983 at 48°50'N, 50°58'W (Table B-1). TAD #2618 and TAD #2625 were deployed respectively on a large tabular iceberg and a small pinnacle iceberg north of the IIP operating area on 22 March 1983 (Table B-1).

While trapped in the sea ice, TAD #2611 moved in a large counter-clockwise circle (Figure B-1). A rapid increase in velocity indicated TAD #2611 broke free from the sea ice on or about 1 May 1983. This large iceberg proceeded in a southward direction along the edge of the Grand Banks. TAD #2611's velocities (based on 12 hour averages) ranged from 1 cm/sec to 89 cm/sec, averaging 33 cm/sec, between 1 May and 27 May. This tagged iceberg was last seen with the TAD aboard on 21 May by Mobil Oil Company, Canada. The size of the iceberg on this date (from a Mobil Oil stereophotograph) was 150m long, 110m wide and 30m above the water. This is a relatively unstable configuration because the center of gravity is extremely close to the center of buoyancy. A major storm system passed through the area on 27 May 1983. There is no assurance after this date that the TAD remained on the iceberg. The winds (based on the FNOC analysis) between 27 May and 14 June, which is the last day information was received from TAD #2611, were:

27 May - 2 June - north to northeast
2 June - 13 June - south to southeast
13 June - 14 June - northerly.

The vast majority of TAD #2611's movement during this period can be accounted for by the wind driven surface current (Figure B-1). It is likely that the storm of May 27 caused the TAD to fall off the iceberg and act as a surface drifter until it terminated transmission on 14 June.

Table B-1

Deployment of Tiros Oceanographic and Arctic Drifters

Buoy Number	Date	Position	SST	Water Depth	Average Pos/Day	Date of Last Report
TOD #2636	21 FEB 83	48°39.2'N 49°58.8'W	-1.4°C	400m	9.4	22 SEP 83*
TOD #2613	21 FEB 83	48°39.0'N 49°00.5'W	-0.8°C	450m	8.9	22 SEP 83*
TOD #2634	24 MAR 83	48°40.0'N 45°30.0'W	2.4°C	1500m	9.5	22 SEP 83*
TOD #2610	8 APR 83	47°00.0'N 47°10.0'W	2.0°C	750m	8.9	22 SEP 83*
TOD #2630	8 APR 83	48°30.0'N 45°00.0'W	2.2°C	900m	8.2	4 AUG 83
TOD #2633	5 MAY 83	48°00.0'N 52°15.0'W	2.8°C	180m	8.7	14 JUN 83
TOD #2632	12 MAY 83	46°50.2'N 47°18.1'W	2.7°C	750m	9.5	22 SEP 83*
			Type Iceberg			
TAD #2618	22 MAR 83	53°00.0'N 54°15.0'W	Large Tabular		9.7	22 SEP 83
TAD #2625	22 MAR 83	53°46.0'N 54°15.0'W	Small pinnacle		2.4	22 SEP 83*
TAD #2611	27 MAR 83	48°50.1'N 50°57.8'W	Large Tabular		7.8	14 JUN 83

* IIP stopped collecting data on 22 September 1983 due to its relocation to Groton, Connecticut.

The movements of TADs #2618 and #2625 were not significantly affected by sea ice (concentrations were less than 4 tenths). TADs #2618 and #2625 entered the IIP operation region on 10 April (52°N, 54°40'W) and 2 May 1983 (52°N, 53°03'W) respectively (Figure B-1). Both TAD #2618 and #2625 moved in an eastward direction at about 14 and 17 cm/sec respectively until reaching about 51°46.8'N, 51°17'W (point A, Figure B-1). They both passed through this point less than eight hours apart. Both TADs changed direction at this point. A high pressure center dominated that area during this time with winds of less than 10 knots (~5 m/sec). The difference in their tracks after Point A may be accounted for by the vast difference in size of the two icebergs. TAD #2618, which made the more pronounced turn after Point A, was a large iceberg with a deep draft. It could have "felt" the Labrador Current more and been less influenced by the wind driven surface current than the small iceberg with TAD #2625 aboard.

From a gross abnormality in the track of TAD #2625 (an unexpected severe change of direction), it is strongly suspected that TAD #2625 fell off the iceberg about 2 June when a storm system passed through the area. This storm system probably caused the iceberg with TAD #2625 aboard either to roll over or break up. The large tabular iceberg with TAD #2618 aboard appears to have weathered this storm but sometime prior to 21 June, TAD #2618 probably fell off. During the period 21-28 June, TAD

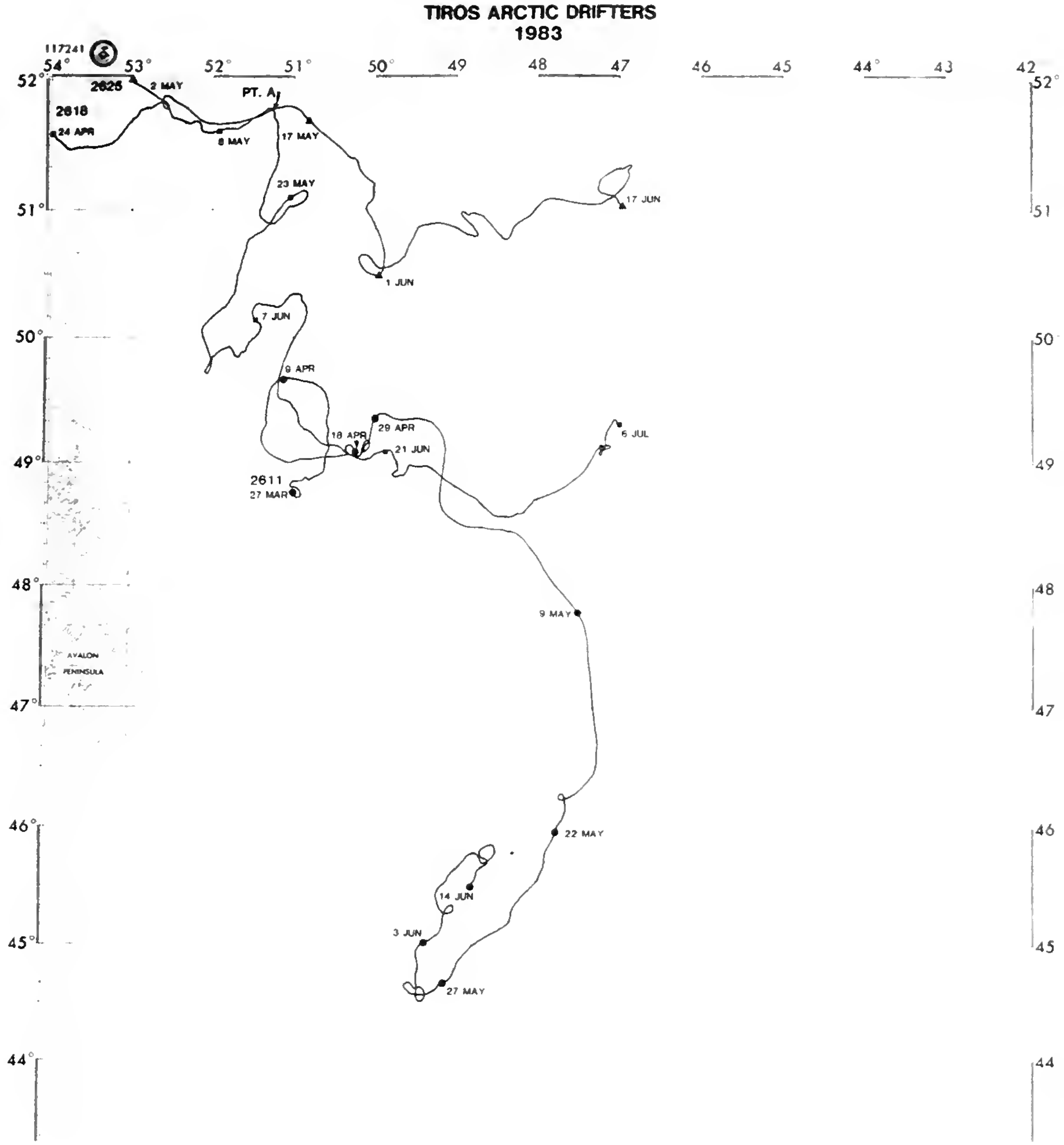


Figure B-1 *Tracks of TIROS Arctic Drifters deployed by IIP during 1983.*

#2618 crossed the Labrador Current perpendicularly. The winds for the period 20-28 June were from the south between 10 and 15 knots. The average movement of TAD #2618 for this period was 114°T at about 16 cm/sec which indicates TAD #2618 was acting as a surface drifter.

The observed TAD "tagged" iceberg movements corresponded well with the movements predicted by the IIP drift model for drift periods less than seven days. For periods longer than seven days, the error accumulated at a much faster rate. The error between actual movement and that predicted by the model was about 5 nm/day for drift periods less than 7 days. Mountain (1980) found errors between actual and predicted iceberg movements of about 6 km/day (~3 nm/day) in evaluating the ICEPLOT model. Therefore the additional use of TADs to evaluate ICEPLOT will be considered.

Considering the time of year and water temperature, it is somewhat remarkable that all of the TADs remained on the icebergs for periods longer that two months. Since all of the TADs remained aboard their respective icebergs for a longer period than expected, the information provided could be used to help tune the IIP iceberg drift model, once the data set is enlarged.

TIROS Oceanographic Drifters

Seven TIROS Oceanographic Drifters (TODs) were deployed during the 1983 IIP season (Table B-1). All of the TODs were deployed with window shade drogues attached to the TOD by a 30m tether. Each TOD was equipped with a sea surface temperature sensor, a drogue tension sensor, and a battery voltage monitor. The position (determined by Doppler shift) and sensor information from each buoy was obtained from Service ARGOS. On 22 September, IIP stopped collecting data from Service ARGOS due to the relocation of IIP to Groton, CT. All drift tracks of the seven TODs are shown in Figure B-2. The velocity distributions are given in Figure B-4.

TOD #2633 was deployed on 5 May 1983 in the Avalon Channel at 48°00'N, 52°15'W (Figure B-2). The buoy proceeded in a southward direction until becoming caught in an eddy near 47°00'N, 52°35'W. TOD #2633 was brought ashore by a fisherman on 14 June. The parachute was still attached to TOD #2633 when it was recovered. It is not known how the drift information obtained from TOD #2633 was affected by the unreleased parachute.

TOD #2634 was deployed from USCGC NORTHWIND north of the Flemish Cap at 48°40'N, 45°30'W. TOD #2634 drifted slowly south around the east side of the Flemish Cap averaging 14 cm/sec for its first 2 months of deployment. About 2 June, TOD #2634 was caught in the North Atlantic Current. From 2 June until 28 June, the average velocity increased to 73 cm/sec. During 7-9 June, TOD #2634 was caught in a meander near 46°45'N, 42°30'W before heading north in the North Atlantic current. After leaving another meander near 50°30'N, 42°20'W on 28 June, TOD #2634 began its journey across the Atlantic. There is no physical evidence in the Canadian METOC sea surface temperature (SST) charts to support the existence of either of the above meanders (Figure B-3).

TOD #2630 was deployed on 21 February 1983 at the top of the Grand Banks at 48°39'N, 49°50'W. It moved southward paralleling the bathymetry of the Banks at an average velocity of 32 cm/sec until crossing 45°N on 18 March. On 12 March the sensor data indicated that the drogue had become disconnected from the buoy. TOD #2630 entered the North Atlantic Current on 21 March. It then moved off to the northeast, averaging 38 cm/sec, until it was caught in a meander near 46°15'N, 42°30'W on about 7 April. TOD #2630 drifted north at 48 cm/sec and was caught in a second meander near 49°30'N, 43°00W before heading east across the North Atlantic.

TOD #2613 was deployed in the entrance to the Flemish Pass at 48°39'N, 49°00'W on 21 February. TOD #2613 proceeded southward paralleling the topography at an average velocity of 27 cm/sec. It entered the North Atlantic current on about 19 March and moved in a northeastward direction until 2 April near 45°30'N, 46°00'W. Between 2 and 22 April, TOD #2613 was caught in an eddy. The Canadian METOC SST charts for that period supports the existence of an eddy in the area. TOD #2613 drifted at an average velocity of 35 cm/sec while trapped in the eddy. After release from the eddy, it moved off at about 75 cm/sec in a northeastward direction until leaving the IIP region.

TOD #2636 was deployed on 8 April 1983 north of Flemish Cap at 48°30'N, 45°00'W. TOD #2636 drifted slowly, averaging about 12 cm/sec, in an eastward direction until 24 April. On that date, it entered the North Atlantic Current and was carried first southeastward and then northward at an average velocity of 51 cm/sec until 1 May. On 1 May, TOD #2636 was caught in an eddy near 49°00'N, 42°45'W. With the exception of two short time periods, it moved with the clockwise circulation of the eddy until the last position was received on 4 August. For the three months TOD #2636 was trapped in this eddy, it moved at an average velocity of 44 cm/sec. The Canadian METOC SST charts show the existence of a warm core eddy near this region for the above time period (Figure B-3).

TOD #2610 was deployed 8 April 1983 in the Flemish Pass at 47°00'N, 47°10'W. TOD #2610 drifted south roughly paralleling the bathymetry of the Grand Banks until it was caught in an eddy near 45°10'N, 48°25'W on 14 April. It travelled northward at 16 cm/sec before being released from the eddy on 9 May. TOD #2610 entered the North Atlantic current on 16 May and four days later was caught in an eddy near 45°20'N, 46°45'W that carried it southward and then southwestward at an average velocity of 33 cm/sec. It was released from the eddy on about 3 July and travelled northeastward at 40 cm/sec with the meanders of the North Atlantic current. The sensor data indicated that the drogue of TOD #2610 was lost on 22 August. The existence of the three eddies was confirmed by the Canadian METOC SST charts (Figure B-3).

TOD #2632 was deployed on 12 May 1983 in the Flemish Pass at 46°50'N, 47°18'W. TOD #2632 drifted southward paralleling the bathymetry until it entered the North Atlantic Current. TOD #2632 was caught in the same ed-

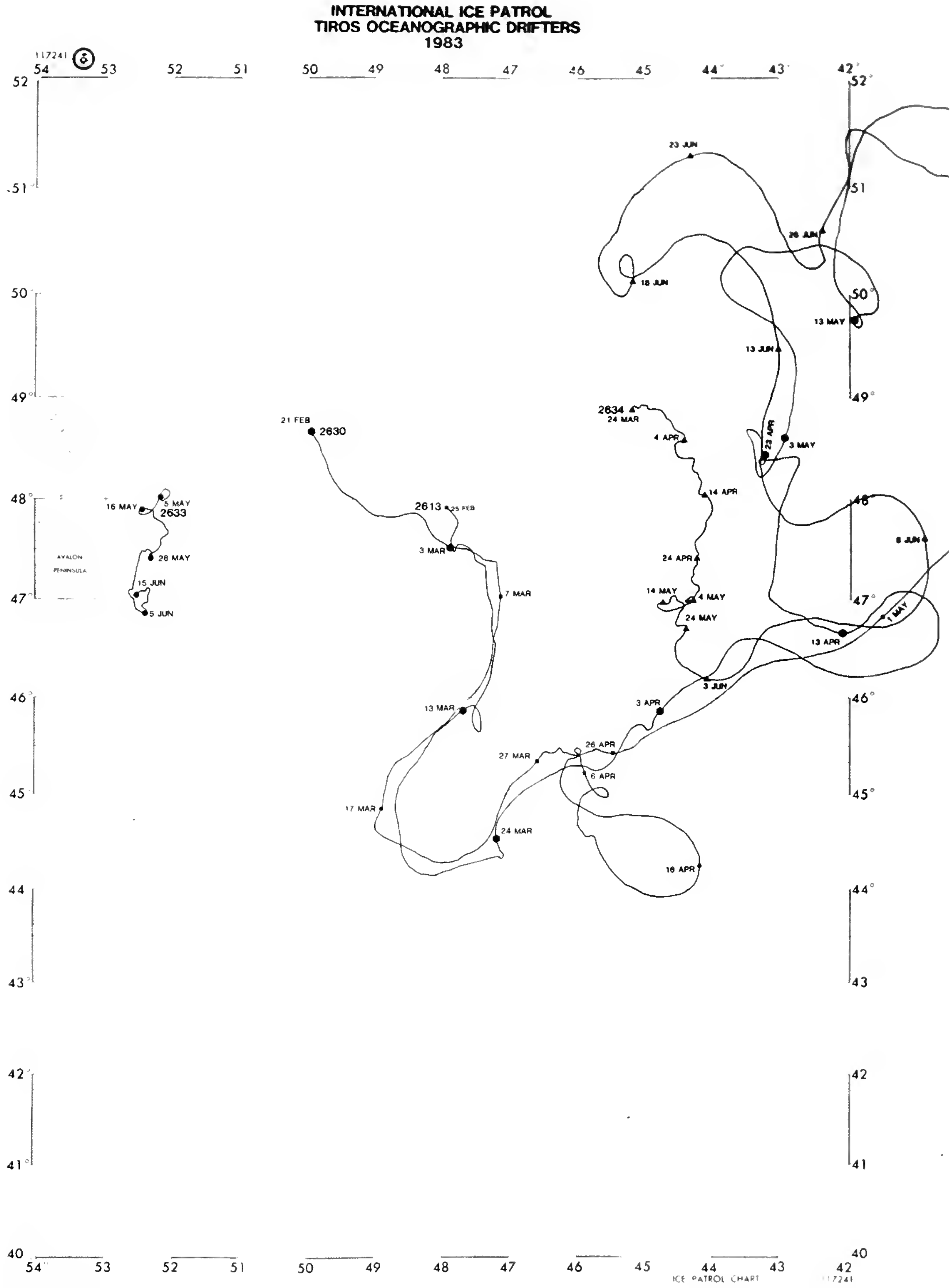


Figure B-2a *Tracks of TIROS Oceanographic Drifters deployed by IIP during 1983.*

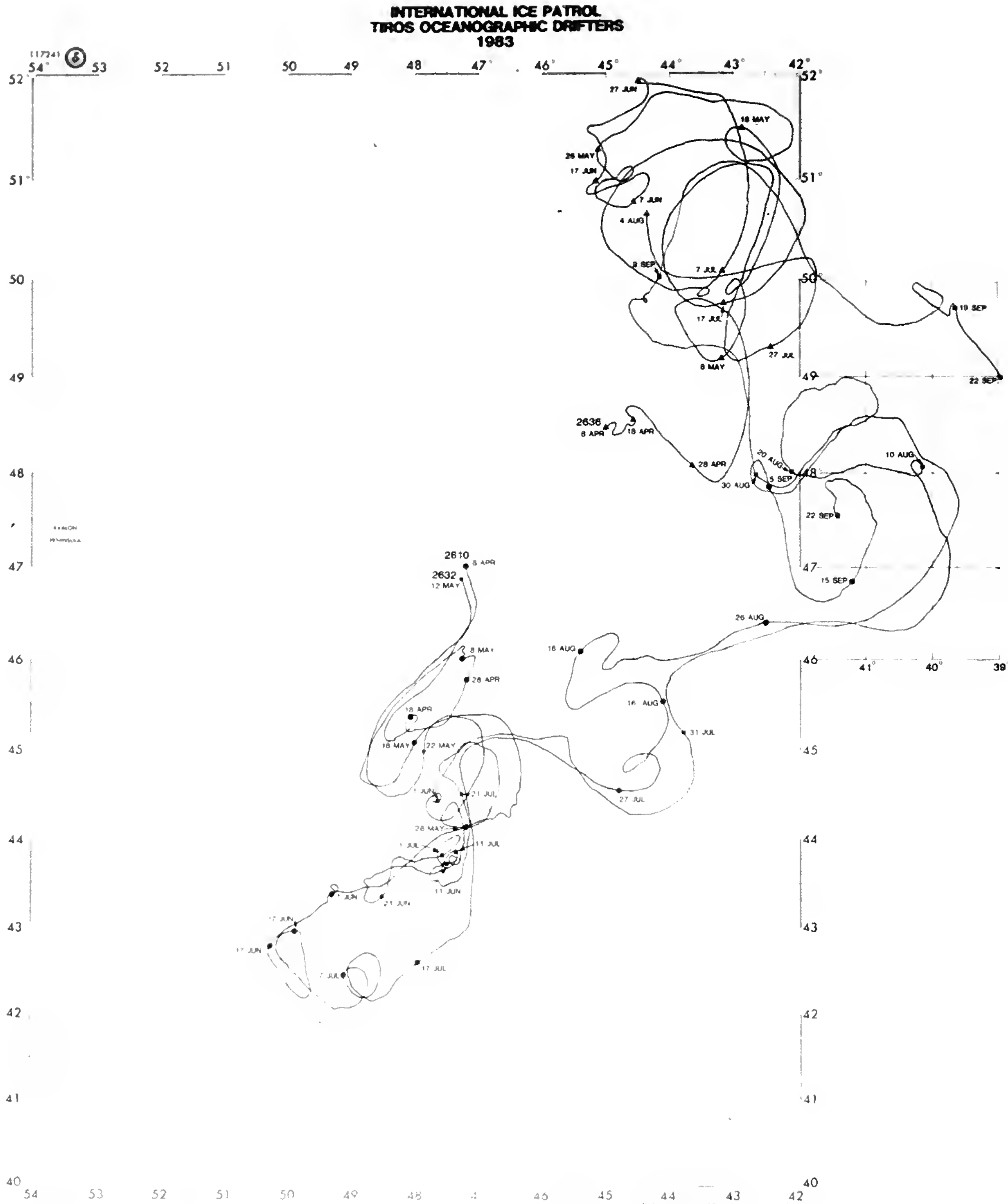


Figure B-2b *Tracks of TIROS Oceanographic Drifters deployed by IIP during 1983.*

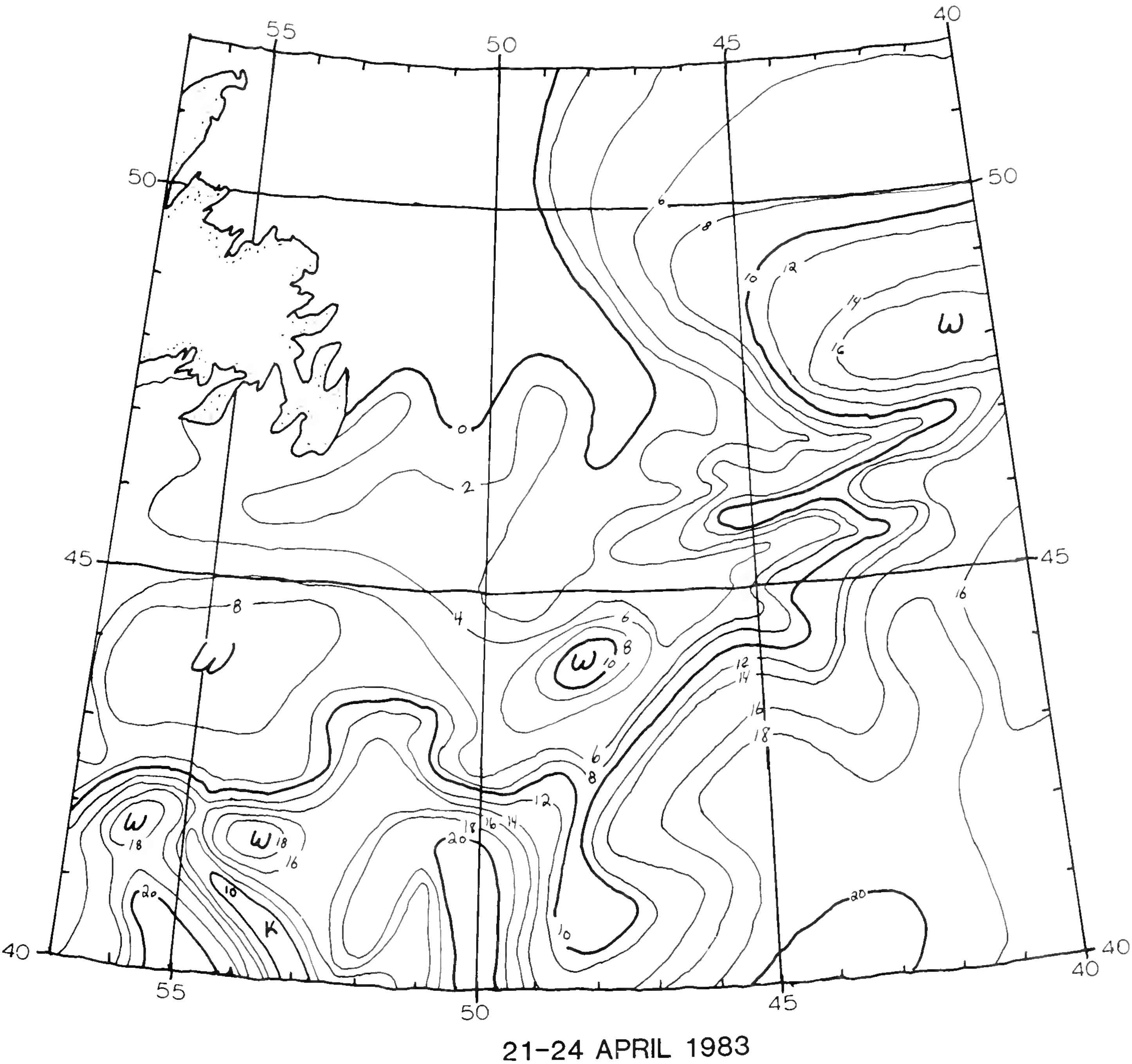


Figure B-3a

Sea Surface Temperatures for Indicated Periods taken from Canadian METOC SST charts.

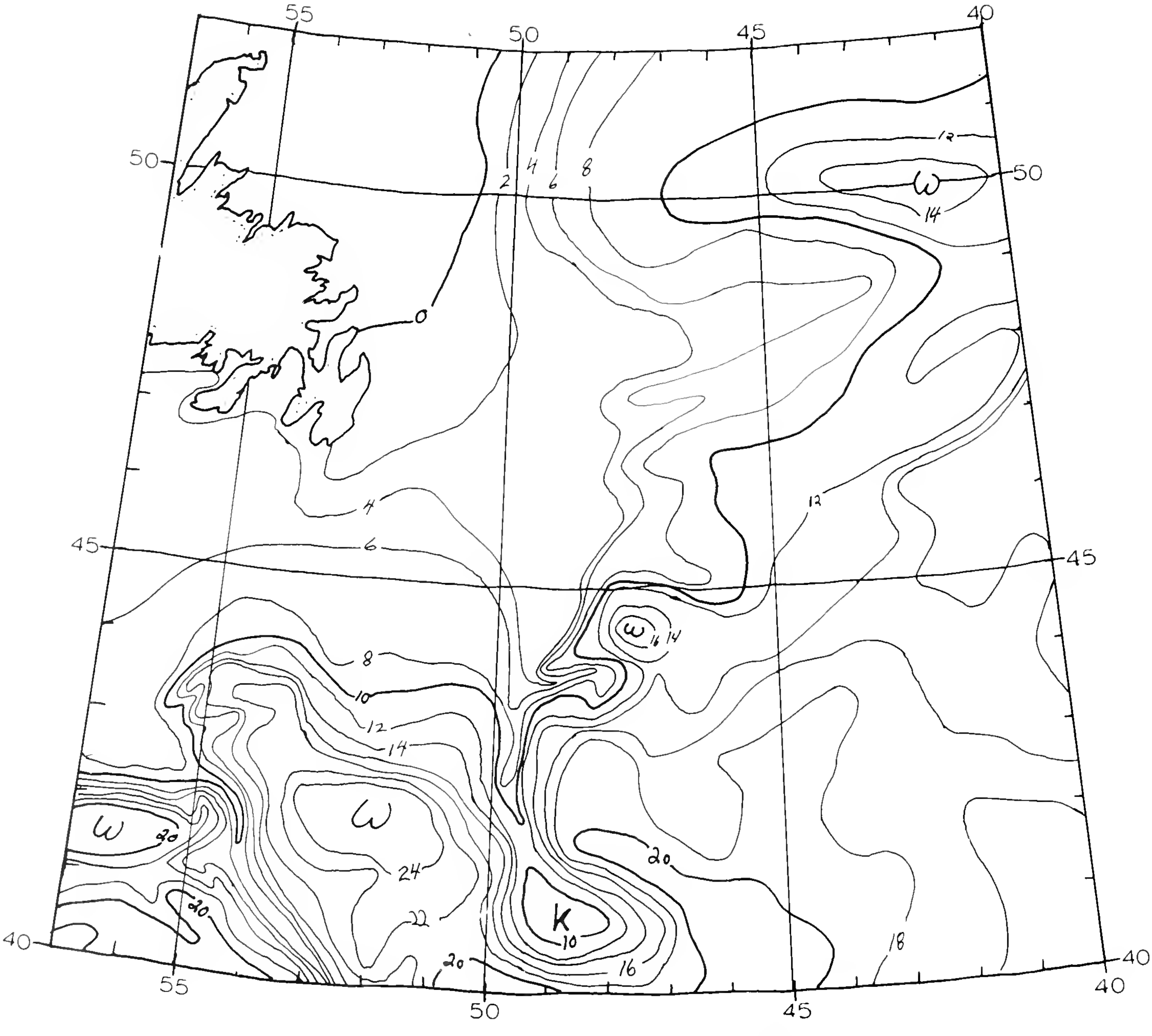


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Figure B-3b

Sea Surface Temperatures for Indicated Periods taken from Canadian METOC SST charts.

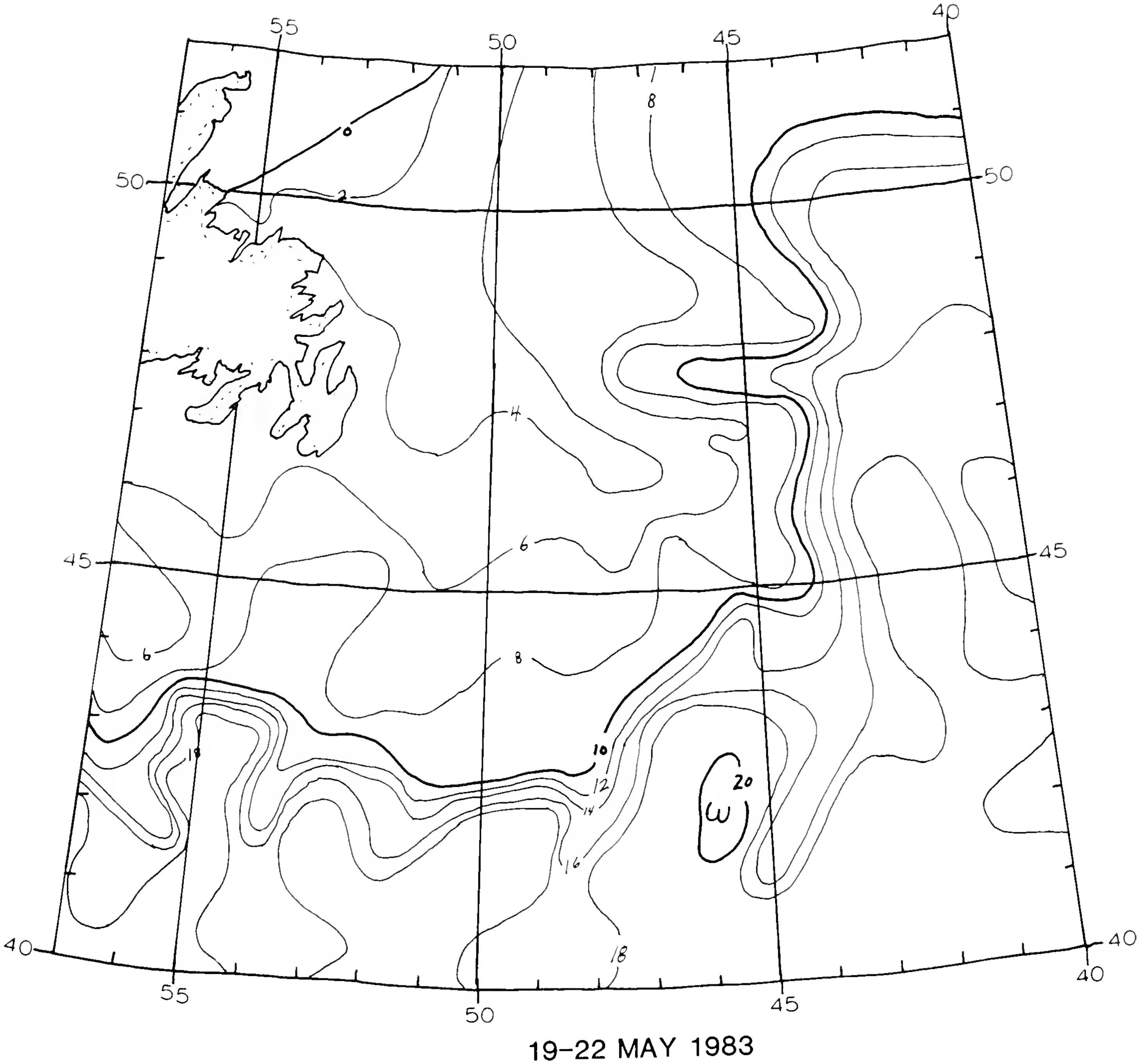


Figure B-3c

Sea Surface Temperatures for Indicated Periods taken from Canadian METOC SST charts.

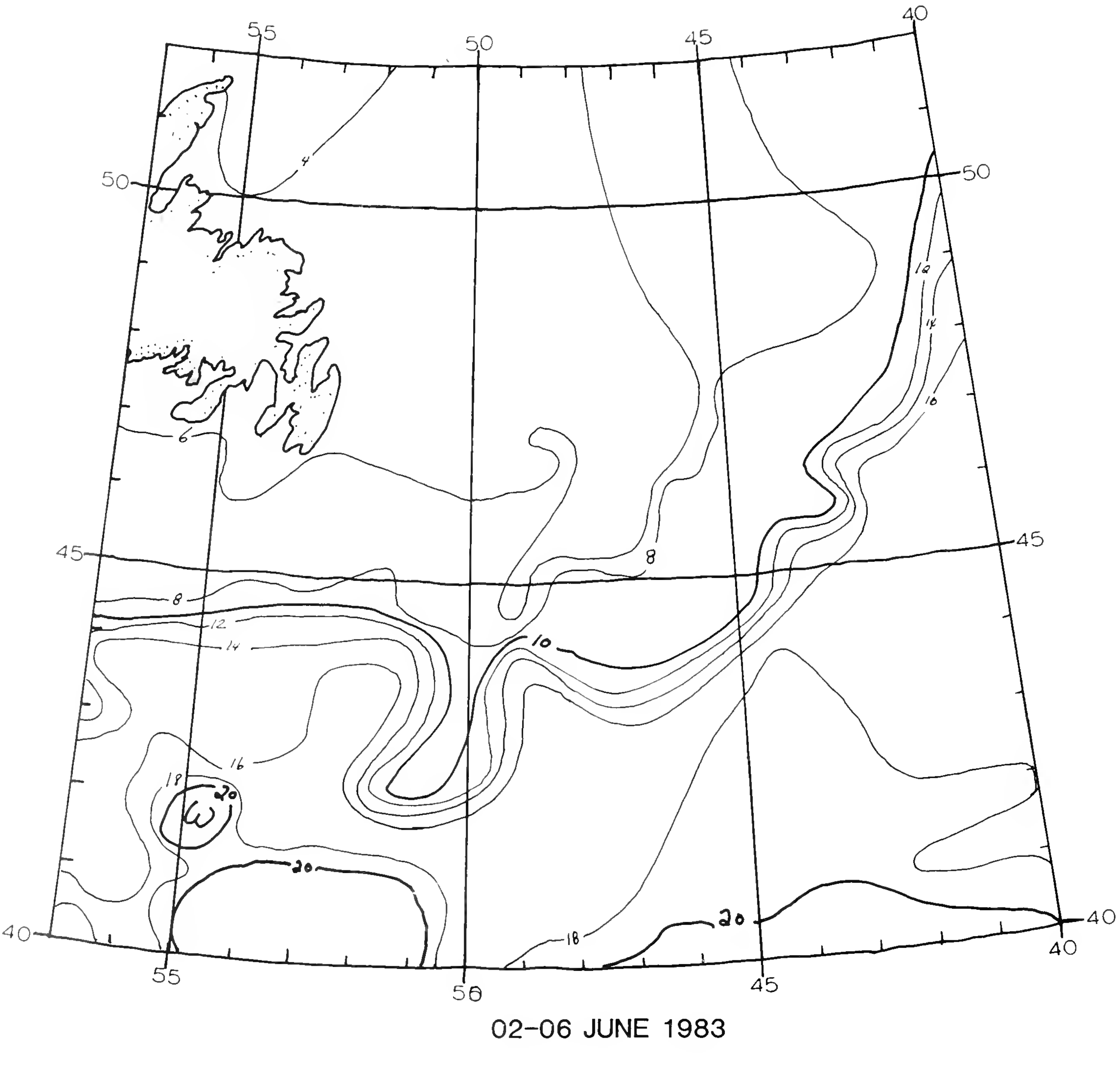
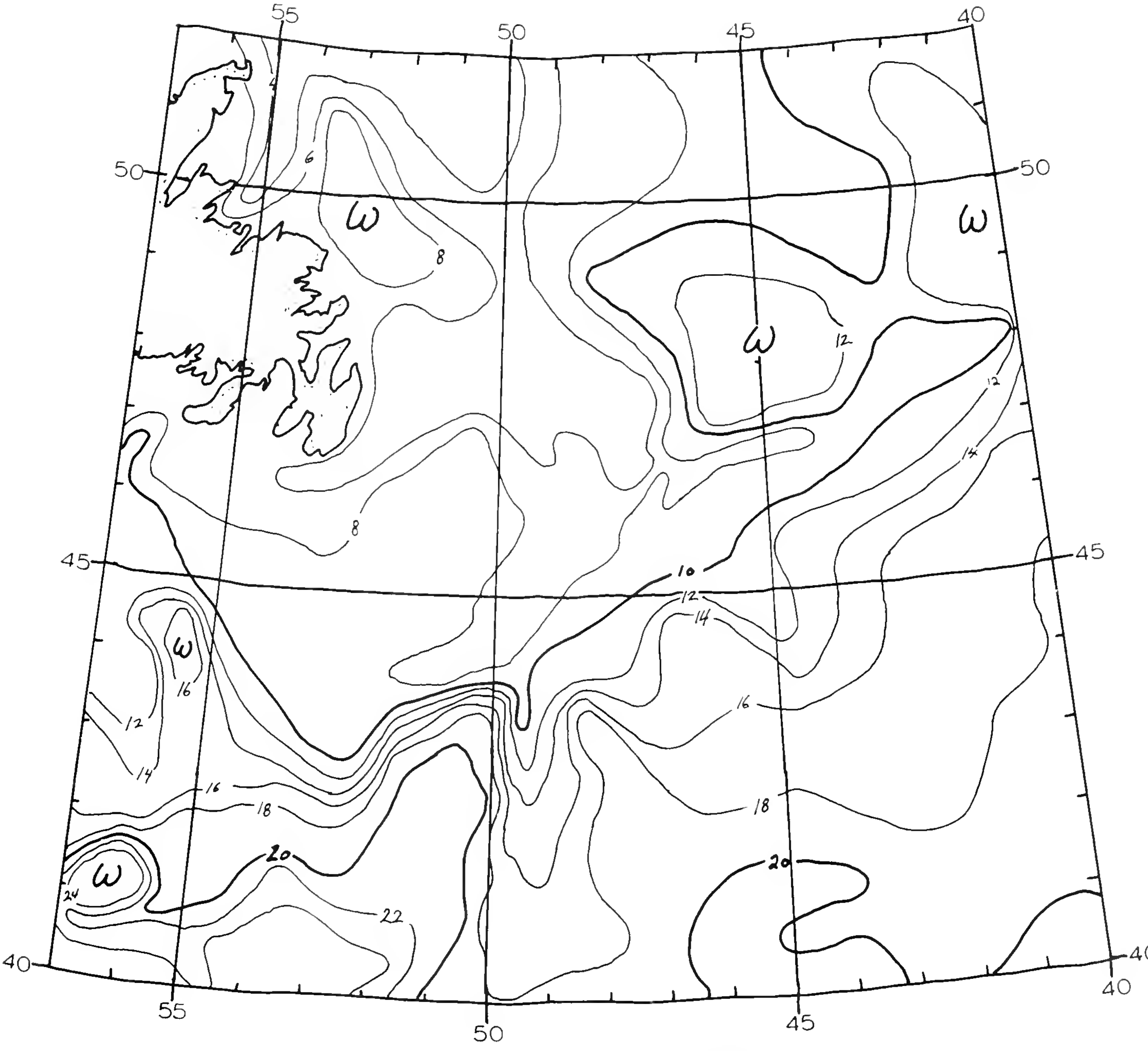


Figure B-3d

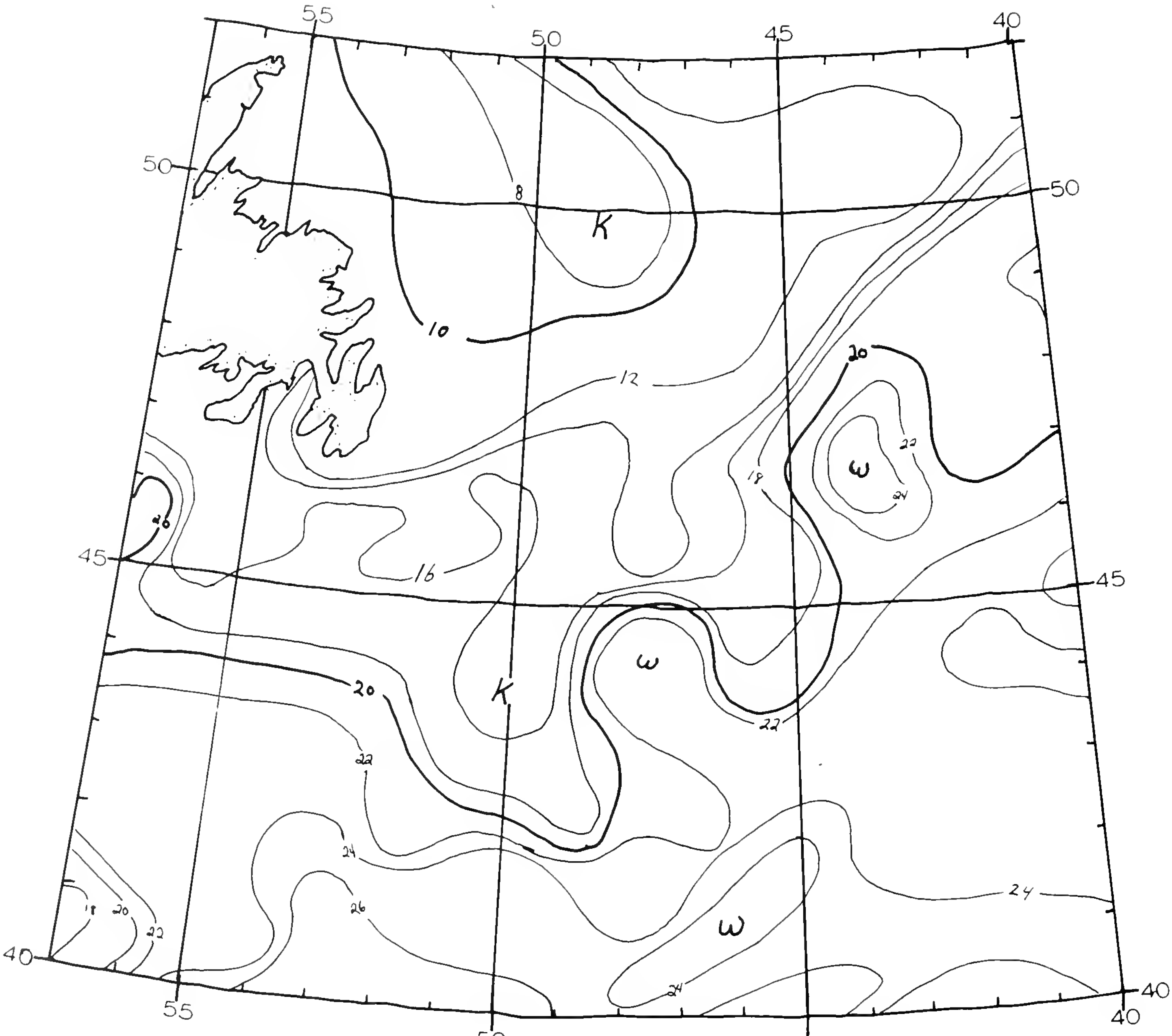
Sea Surface Temperatures for Indicated Periods taken from Canadian METOC SST charts.



16-19 JUNE 1983

Figure B-3e

Sea Surface Temperatures for Indicated Periods taken from Canadian METOC SST charts.



04–07 AUGUST 1983

Figure B-3f

Sea Surface Temperatures for Indicated Periods taken from Canadian METOC SST charts.

dy as TOD #2610 on 24 May and was carried southward and then southeastward. The sensor data indicated that its drogue became disconnected on 24 May 1983. TOD #2632 remained in the eddy averaging 27 cm/sec until exiting the eddy on 20 July. It followed the meanders of the North Atlantic Current northeastward at 65 cm/sec until 6 August when it turned and drifted northwestward. TOD #2632 made two counter-clockwise circles about two separate eddies and then began its eastward journey across the Atlantic Ocean in the North Atlantic Drift on 12 September. Between 6 August and 12 September, TOD #2632 averaged 55 cm/sec. The Canadian METOC SST charts support the existence of all the eddies shown by TOD #2632's tracks.

In summary, all of the TODs drifting southward along the northern extremity of the Grand Banks were guided bathymetrically in their journey south. The past years TODs in this region appear to have been guided bathymetrically (Shuhy, 1981; Summy, 1982). All four of the TODs drifting through the Flemish Pass this year, entered circulation dominated by the North Atlantic Current at nearly the same position, independent of the time of year. With the exception of TOD #2633, the TOD velocity distributions were not significantly different (Figure B-4). Of the five TODs which crossed 42°W between 46°N and 47°N, only one (TOD #2613) did not circle back west of 42°W and then travel northward. This feature has been observed in the previous years' drift tracks. All of the TODs that have travelled northward, including drifts of previous years, have been caught in what appears to be a stationary meander of the North Atlantic Drift centered roughly at 50°N, 43°W. This feature was clearly portrayed by the Canadian METOC SST charts of the area for most of the 1983 IIP season.

Modification of the IIP Historical Current Field

The validity of certain regions of the IIP historical current field had come under suspicion because of the differences between computer-predicted iceberg positions and those of actual resights. The most prevalent area in which this occurred was north of the Flemish Cap.

The criteria selected for making changes to the historical geostrophic current field were:

a. A minimum of five TOD tracks passed through the same 1° latitude by 1° longitude rectangle.

b. The speed and direction of the TODs through each selected rectangle must have been reasonably similar.

The time of the year of the TODs' passage through the rectangle was not a factor since the current field used by IIP is considered independent of time. This selection method should eliminate those differences caused solely by eddies or other short term oceanographic features.

Three 1° latitude by 1° longitude rectangles met the criteria described above for making changes to the current field. The three rectangles selected were between 48°N and 49°N and 46°W and 49°W (Figure B-5). TODs from four different years passed through this area and are included in Figure B-5. Some significant changes were made to the historical current field, changing directions by 180° and velocities by an order of magnitude. The changes to this region of the current field were made prior to the 1983 ice season. Future changes of the current field using the above criteria will be done as necessary.

Summary

The real-time current information provided by the TODs allowed the International Ice Patrol to improve the accuracy of the iceberg information disseminated to the maritime community. The ability to obtain real-time current information is a valuable tool and not available by any other more cost-effective means. The ability to modify with some confidence the IIP historical current base solely on TOD drifts was an unanticipated use of this data. As seen in this year's drifts and those of previous years (Shuhy, 1981; Summy, 1982) topographic steering appears to be an important process in guiding drifting objects in the area of the Grand Banks.

For the upcoming 1984 Ice Patrol season, a subroutine to handle icebergs grounding on the coast has been added. In the past, the ICEPLOT program treated land as an area of 0 cm/sec geostrophic current. If the wind driven current was from the "wrong" direction, icebergs would "drift" across land. Icebergs would have to be moved by the operator back to the position they entered land. For the 1984 Ice Patrol season, icebergs will automatically be stopped at the coastline and will be flagged as grounded. During the 1984 season, another subroutine will be added to ground icebergs based upon their size and the bathymetry of the area. These two additional routines should enhance the accuracy of the iceberg information disseminated by the International Ice Patrol.

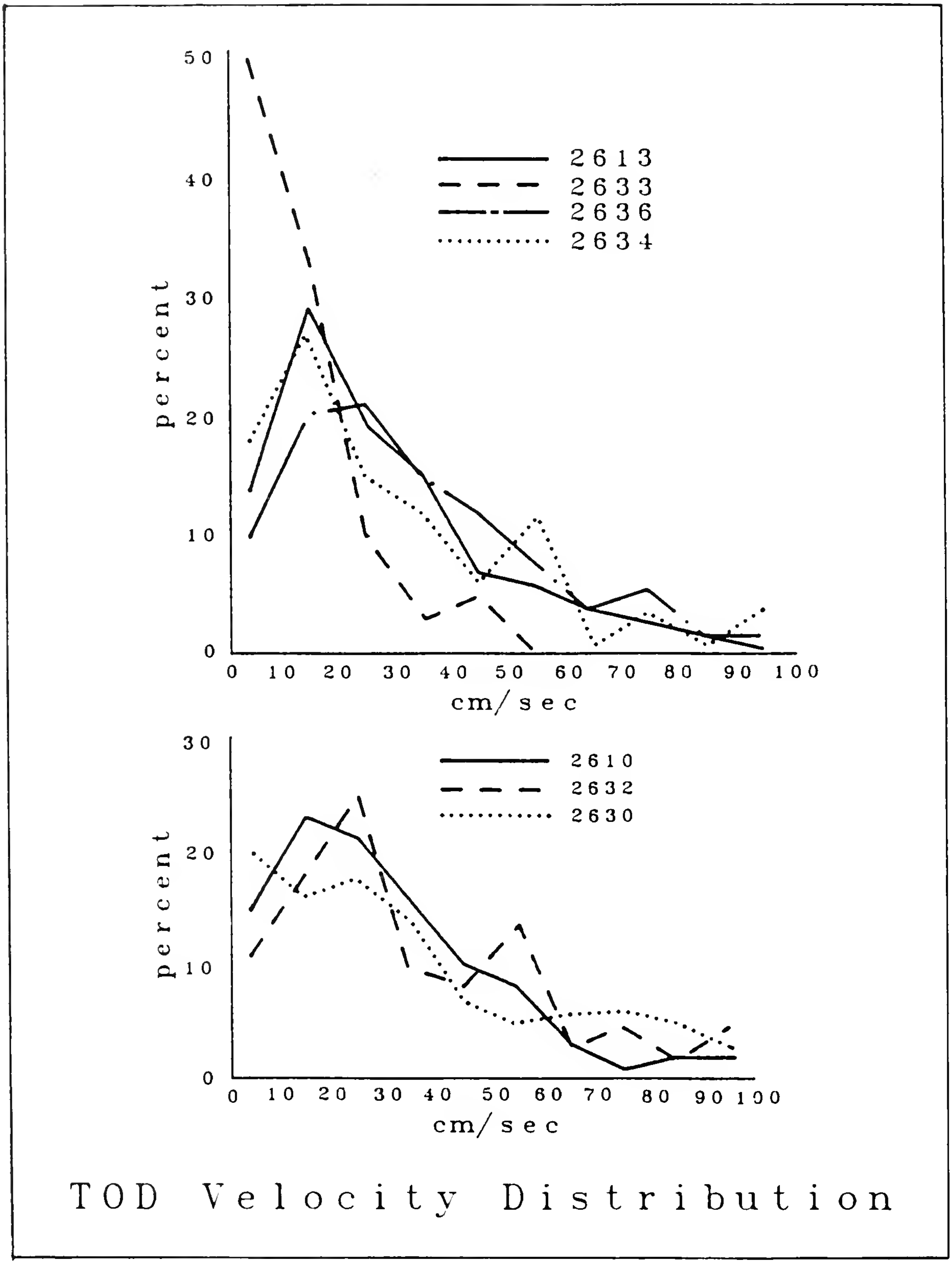


Figure B-4

1983 TOD Velocity Distributions based upon 12 hourly average velocities.

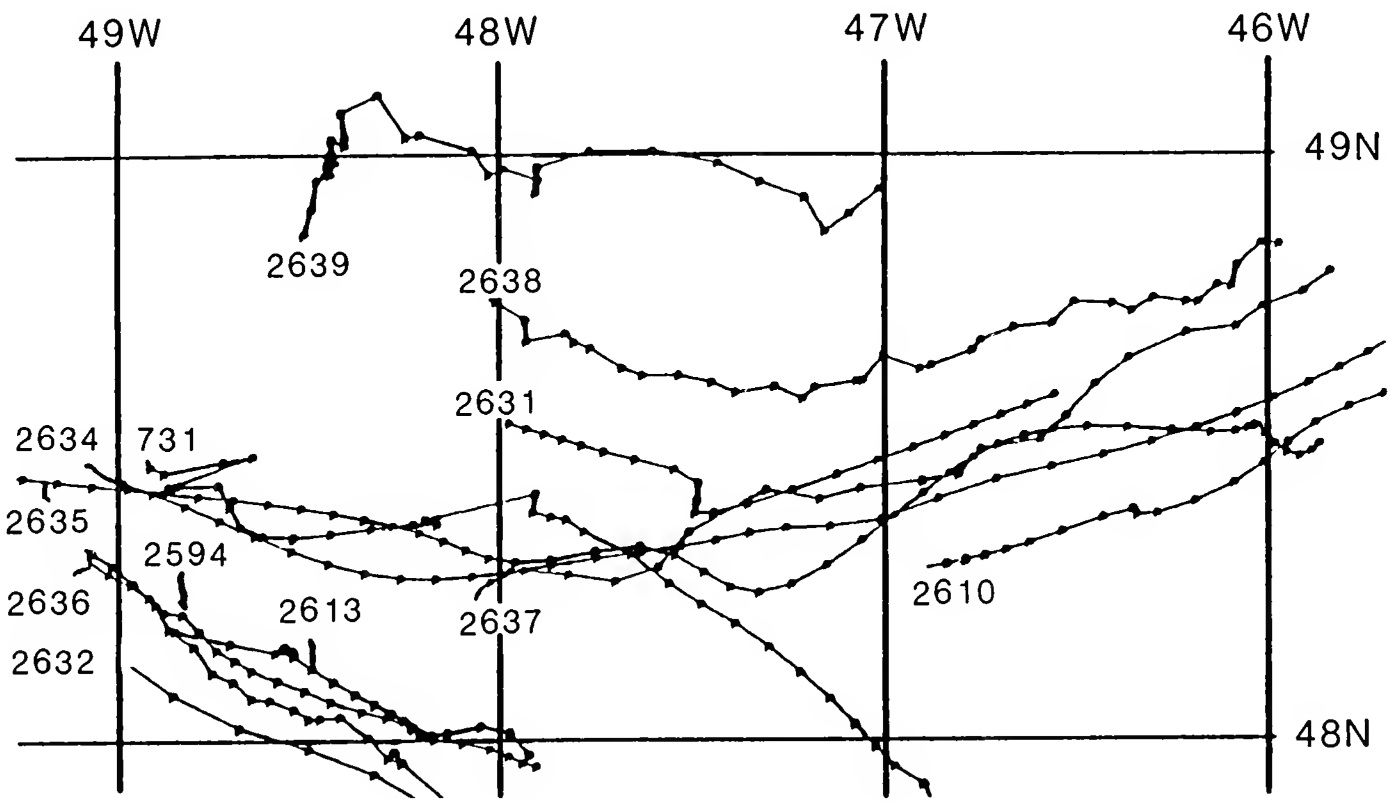


Figure B-5

TOD tracks through area where IIP Historical Current File was modified, based solely on TOD drifts.

References

Shuhy, J. L. "Oceanographic Conditions on the Grand Banks During the 1981 Ice Patrol Season"; Appendix C, Report of the International Ice Patrol Service In the North Atlantic Ocean, Season of 1981 (CG-188-36), 1981.

Summy, A. D. "Oceanographic Conditions on the Grand Banks During the 1982 Ice Patrol Season"; Appendix C, Report of the International Ice Patrol Service In the North Atlantic Ocean, Season of 1982 (CG-188-37), 1982.

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Appendix C

Iceberg Deterioration Model

By Lieutenant Iain Anderson

Introduction

The ICEPLOT computer program used by the International Ice Patrol (IIP) to predict the positions of reported icebergs depends on iceberg size. It is well known that icebergs drifting south in the IIP operating area (between 40°N-52°N and 57°W-39°W) deteriorate. The need for an iceberg deterioration model has existed for some time. Previously, IIP used a hand-held calculator deterioration scheme that was based solely on sea surface temperature. In 1980, Coast Guard Research and Development Report No. CG-D-62-80, "Theoretical Estimate of the Various Mechanisms Involved in Iceberg Deterioration in the Open Ocean" (White, et al., 1980) was completed. The R&D Center report discussed some of the physics involved in buoyant convective, wind forced convective, insolation, and wave erosion melting. All equations and figures referenced in this paper refer to this R&D Center report.

In order to make use of the equations in the R&D Center report, real-time environmental information (sea surface temperature (SST), wave height, and wave period) for the IIP operating area had to be obtained. The required environmental information was obtained from the Fleet Numerical Oceanography Center (FNOC), Monterey, California on a one degree latitude by two degree longitude grid. An evaluation of this data is discussed later.

The Model

The two planned uses of the deterioration model are to change the size of the iceberg as it melts so the berg could be drifted more accurately and to remove the iceberg from the list of active bergs when it has completely melted. Until more evaluations of the model have been completed, the model will be used only to "flag" bergs that have accumulated a "melt" greater than 175% of their original length. Presently the model is run once a day.

The output from the deterioration model is presented in an easy-to-interpret form. The form is a number that represents the percentage of the original length that has been melted by the model. The model requirements are:

- any assumptions made are to be conservative; i.e., they will cause the berg to melt more slowly.
- the model can be integrated into the existing ICEPLOT computer package.
- equations used are to be relatively simple to program and produce an answer accurate within the error limits of the inputs.

Each size of iceberg is assigned a characteristic length (Table C-1). The lengths assigned, except for the large bergs, are those used by IIP to classify icebergs. The length used for the large iceberg was chosen arbitrarily. "Melting" each iceberg reduces the length of the iceberg. This is the method used in the R&D Center report. The percent melt output of the model is the total length removed from the melting iceberg divided by the characteristic length of the berg multiplied by 100 (to make the output in percent). The four melting processes programmed are discussed below in order of increasing importance (Table C-2).

Table C-1

Size	Characteristic Length
Growler	16 m
Small	60 m
Medium	122 m
Large	225 m

Characteristic Iceberg Lengths Used in Deterioration Model

Table C-2

Melting Caused by	Deterioration	Percent of Total
Insolation	0.02 m/day	0.3%
Buoyant convection	0.12 m/day	1.6%
Wind Forced convection	0.93 m/day	14.2%
Wave Induced	6.55 m/day	84.0%

Deterioration caused by each of the considered methods over one day assuming: Wave height = 6', Wave period = 10 sec, and Relative Velocity = 25 cm/sec.

Insolation melting is relatively unimportant in the model. R&D Center report figure #22 (Figure C-1) is the basis for the equation:

$$SUN = 2.0*WEATHER*(0.5*ZTIME)/100 \qquad (1*)$$

where SUN is in meters/day, ZTIME is in units of half days (hence the 0.5) and the factor of 100 converts centimeters to meters. WEATHER is set to 1 for cloudy/foggy conditions and to 2 for clear conditions. The weather in the IIP operating area is generally not clear, therefore weather will be assumed always to be 1 for the model. The 2.0 is taken as the smallest melt rate (in cm/day) that covers the time period of the average IIP season (March - August) (Figure C-1).

Neshyba and Josberger (1979) estimate vertical buoyant convective melting as (White, et al., 1980):

$$v_m(m/yr) = 2.78*T + 0.47*T^2 \qquad (2*)$$

where T is the temperature difference between SST and ice surface temperature. This equation was derived from data on a wide variety of iceberg shapes. The temperature of the ice surface was chosen as -1 °C. This temperature is above the equilibrium temperature of ice and sea water at 30 parts per thousand salinity of -1.63 °C. An ice surface temperature of -1 °C will be used throughout the model. The equation used to model vertical buoyant convective melting is:

$$BUOY = 0.274*(2.78*T + 0.47*T^2)*ZTIME*0.5/100$$

where 0.274 converts m/yr to cm/day. As shown by White, et al., 1980, this equation agrees well with the other equations used to model vertical convective melting.

The equations used to model melting caused by wind-forced convection are derived from the R&D Center report No. CG-D-62-80 (Figure C-2). There appears to be a change in the slope of the linear approximation of the plotted curves at a relative velocity of about 25 cm/sec. A plot of the slope of the linear approximation rate for melting versus the $\log_{10}$ of the waterline length of an iceberg was made for relative speeds less than 25 cm/sec and for the section greater than 25 cm/sec (Figure C-3). The resulting linear regression for each set of points was determined as:

- for the portion of the relative velocity < 25 cm/sec:

$$0.934 - (0.202 * \log_{10}(RLEN)); \qquad (4*)$$

- for that part of relative velocity > 25 cm/sec:

$$0.660 - (0.151 * \log_{10}(RLEN)), \qquad (5*)$$

where RLEN is the present waterline length of the iceberg. The wind forced convective melting factor (FC) is calculated from equations 4* and 5*:

$$FC(cm/day/°C) =$$

$$(0.934-(0.202*\log_{10}(RLEN))*RELSPD \qquad (6*)$$

$$FC = (0.660-(0.151*\log_{10}(RLEN))*(RELSPD-25) +$$

$$(0.934-(0.202*\log_{10}(RLEN)*(25) \qquad (7*)$$

where RELSPED is the relative speed of the iceberg with respect to the historical geostrophic current. Equation (6*) is used when the relative velocity is less than 25 cm/sec and equation (7*) is used when the relative velocity is greater than 25 cm/sec. RELSPED is calculated by determining the (N-S, E-W) components of the distance traveled between two analysis time periods, dividing by the time difference and then subtracting the historical geostrophic current. The magnitude of the vector (RELSPED) is then determined. There is an admitted error in this calculation because at present neither the wind driven current nor inertial effects are taken into account. Five cm/sec is added to the relative velocity since this is the average value of water velocity observed in calm conditions (White, et al., 1980). FC is

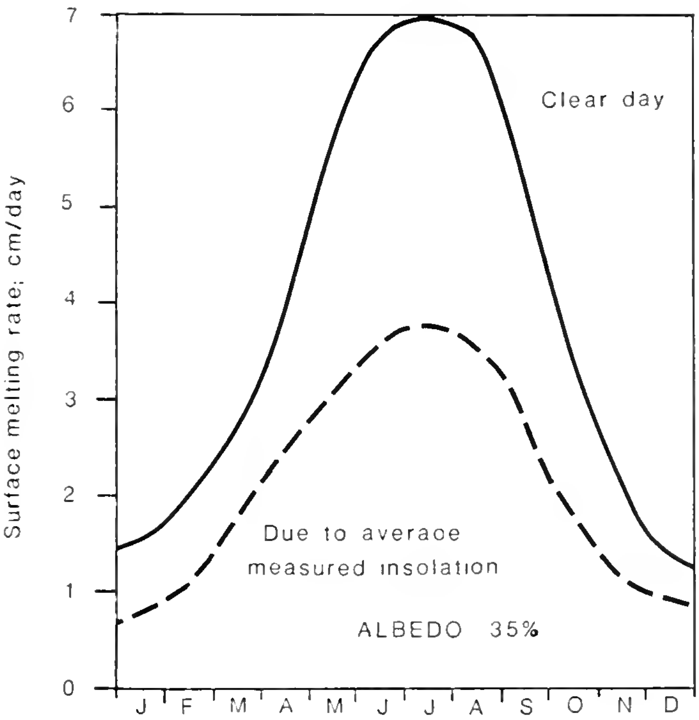


Figure C-1

Iceberg surface melting rate due to insolation at 50° N latitude

(White, et al: 1980)

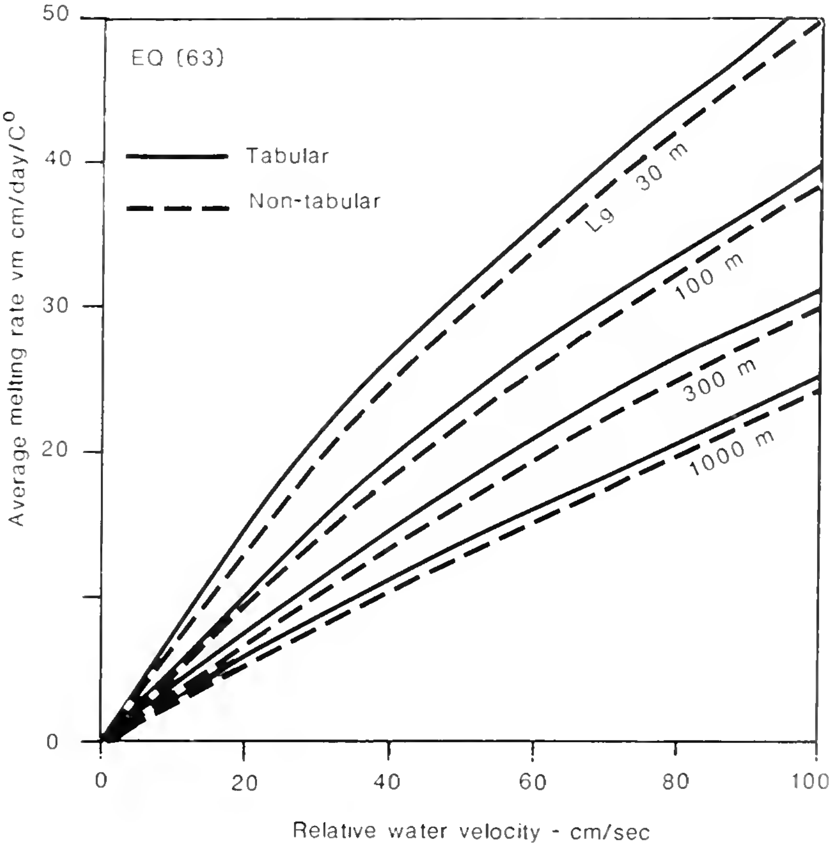


Figure C-2

Theoretical iceberg average melting rate due to forced convection for various waterline lengths

(White, et al: 1980)

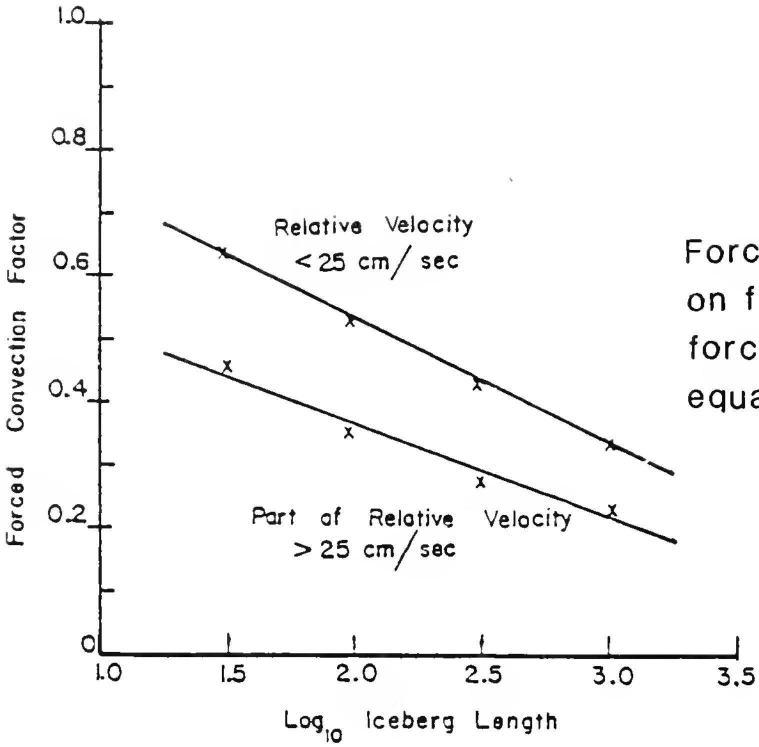


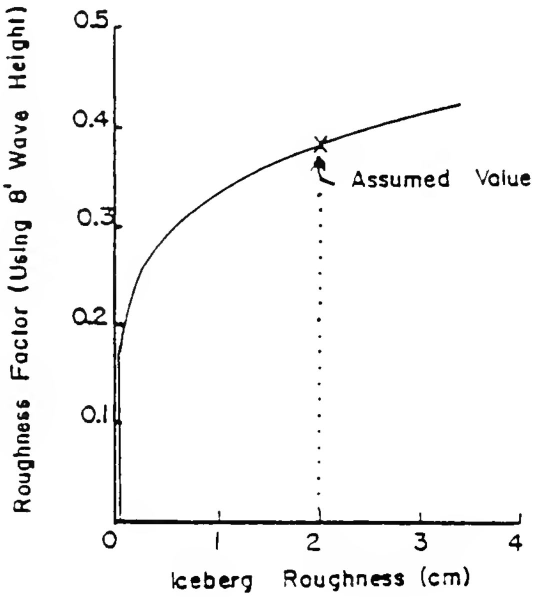
Figure C-3

Forced convective factor based on figure C-2 used in wind-forced convective melting equation

Roughness Factor = (Iceberg Roughness/Wave Height)$^{0.2}$

Figure C-4

Effect of iceberg roughness on wave erosion



multiplied by T and ZTIME to obtain the amount of deterioration due to wind forced convection:

$$WINFO = FC*T*ZTIME*0.5/100 \quad (8*)$$

As can be seen in Table C-2, wave erosion is the most important method of iceberg deterioration. Since there is no realistic method to model calving caused by wave erosion, calving has been ignored. The equation selected to model deterioration caused by wave erosion is (White, et al., 1980):

$$V_m * t/H = 0.000146(E/H)**0.2 \quad (9*)$$

where t is wave period in sec, H is wave height in centimeters, E is the height of the roughness on the iceberg wall in centimeters, and V_m is the melting in m/sec/°C. This equation is solved for melting rate in meters per day:

$$WAVE = (XAMP*0.000146*(2.0/XAMP)**0.2*24*3600$$

$$*ZTIME*0.5/IPER*T/100 \quad (10*)$$

Where XAMP is wave height in centimeters, IPER is wave period in seconds. In order to use the selected equation, a value for the roughness on the iceberg wall had to be assumed. A value of 2.0 cm was chosen. The effects of selecting another value for iceberg roughness is shown in Figure C-4. The shape of the curve between 1 and 3 cm does not change significantly with wave height.

The total melt for the time period between the present analysis run and the previous run is calculated:

$$XMELT = BUOY + WINFO + WAVE + SUN \quad (11*)$$

and then a total melt percent is calculated:

$$PERMELT = PERMELT + ((XMELT/CHARL)*100) \quad (12*)$$

where CHARL is the characteristic length of the appropriate size of iceberg. These calculations are performed for each berg. When PERMELT (the percent of the original length that has melted) exceeds 175%, a flag is printed on the output listing notifying the operator that the berg should be considered for deletion from the active berg file.

Environmental Inputs

Sea surface temperature (to nearest °C), wave height (to nearest foot), and wave period (to nearest two seconds) analysis for 0000Z and 1200Z are received daily from FNOC. The information is interpolated by FNOC and is received by IIP on a 1° latitude by 2° longitude grid. There are occasions when some of the points on the grid are not determined (values are set to zero) or one or more of the products are not available. Setting a missing parameter (except SST when the actual SST is below zero) to zero will make an iceberg melt slower. If a parameter file has not been updated, the latest available information will be used when the deterioration model is run.

The most critical parameter received from FNOC is sea surface temperature. Temperature is a controlling factor in equations (3*), (8*), and (10*). As can be seen in Table C-3, an error in temperature, particularly when the overall sea surface temperature is low, will have significant effects on the melting rate of an iceberg.

The FNOC environmental inputs were evaluated this spring during an IIP cruise and a transit of the IIP area by USCGC NORTHWIND. Hourly measurements of sea surface temperature and wave height were taken over the two periods, totalling about eight days. During a six day period in March, the actual sea surface temperature compared well with the predicted values from FNOC. The difference was always less than 1°C (maximum temperature in area surveyed was 4.8°C). The differences observed in a two day transit of the area in June were higher, with a maximum difference of 3.3°C. In nearly all cases, the observed temperature was more than the predicted temperature. This error would cause the actual rate of deterioration to be faster than that predicted by the model.

The observed wave height was consistently less than that predicted by FNOC during the eight-day period. The largest observed difference was 22 feet. The differences between the observed and the predicted wave heights appeared to increase with the height of the predicted waves. This error would cause the predicted deterioration rate to be faster than the actual rate.

Table C-3

SST	Number of Days
-1°C	179.0
3°C	20.5
6°C	12.0
10°C	8.0
15°C	5.0

Number of days required to melt a 100 meter iceberg at a given Sea Surface Temperature assuming: Wave height = 6', Wave period = 10 sec and Relative Velocity = 25 cm/sec.

Model Evaluation

No field evaluations of the deterioration model were conducted this year, although two were planned. Evaluations are planned for next year. The evaluations will consist of measurements of the environmental factors and the response (deterioration) of the iceberg to the observed parameters over a period of several days. Attempts will be made to observe several different sizes and types of icebergs.

The results of ice reconnaissance flights by IIP provided a preliminary evaluation of the deterioration model. The model was evaluated from the results of the flights using the following criteria:

- icebergs were identified as being removed from the active berg list as a result of an ice reconnaissance flight.
- the melt percent predicted by the model for the icebergs removed from the list was tabulated (Table C-4).
- icebergs that had been on plot less than four days and removed were not considered for inclusion in Table C-4. These bergs were assumed to be improperly interpreted SLAR targets when not resighted by a subsequent ice reconnaissance flight.
- icebergs that were in areas of no environmental data, i.e., areas close to the coast, were not included in Table C-4.

NOTE: Bergs whose melt percent exceeded 175% were being removed on a daily basis including the days of ice reconnaissance flights.

The results shown in Table C-4 are encouraging. Part of the 18% of the icebergs being removed with a melt percent less than 66% can be accounted for by improper sizing of SLAR targets. Approximately 97% of all icebergs entered into the model this year were SLAR targets interpreted as icebergs. No attempt was made to evaluate resighted berg sizes to check if the new observed length corresponded with the length predicted by the model because the sizing information of SLAR iceberg targets had not been verified.

After the model has been thoroughly evaluated, the model can be integrated into the ICEPLOT program package where automatic downgrading of iceberg sizes and removal of melted icebergs will be possible. Before this can be accomplished, several years of evaluations will need to be completed.

One other method used to evaluate the deterioration model was to review iceberg deterioration described in the literature and compare these with the deterioration predicted by the model. Two bases for this comparison were found (Robe, et al., 1977 and Kollemeyer, et al. 1966). In both instances the actual deterioration of the iceberg was faster than that predicted by the deterioration model. This is a positive result since the model was designed to be conservative. The iceberg deterioration model, in the meantime, can be used as another tool in disseminating, as accurately as possible, iceberg information to the maritime community.

Table C-4

Month	Less than 66%	Between 66% and 100%	Greater than 100%	Total
February	5	8	15	
March	25	32	15	
April	19	28	23	
May	24	70	58	
June	5	17	14	
July	14	39	91	
August	3	5	6	
Totals	95	199	222	516
Percent	18%	39%	43%	

Model percent melt of icebergs removed from the active berg file as a result of IIP ice reconnaissance flights during the 1983 season.

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